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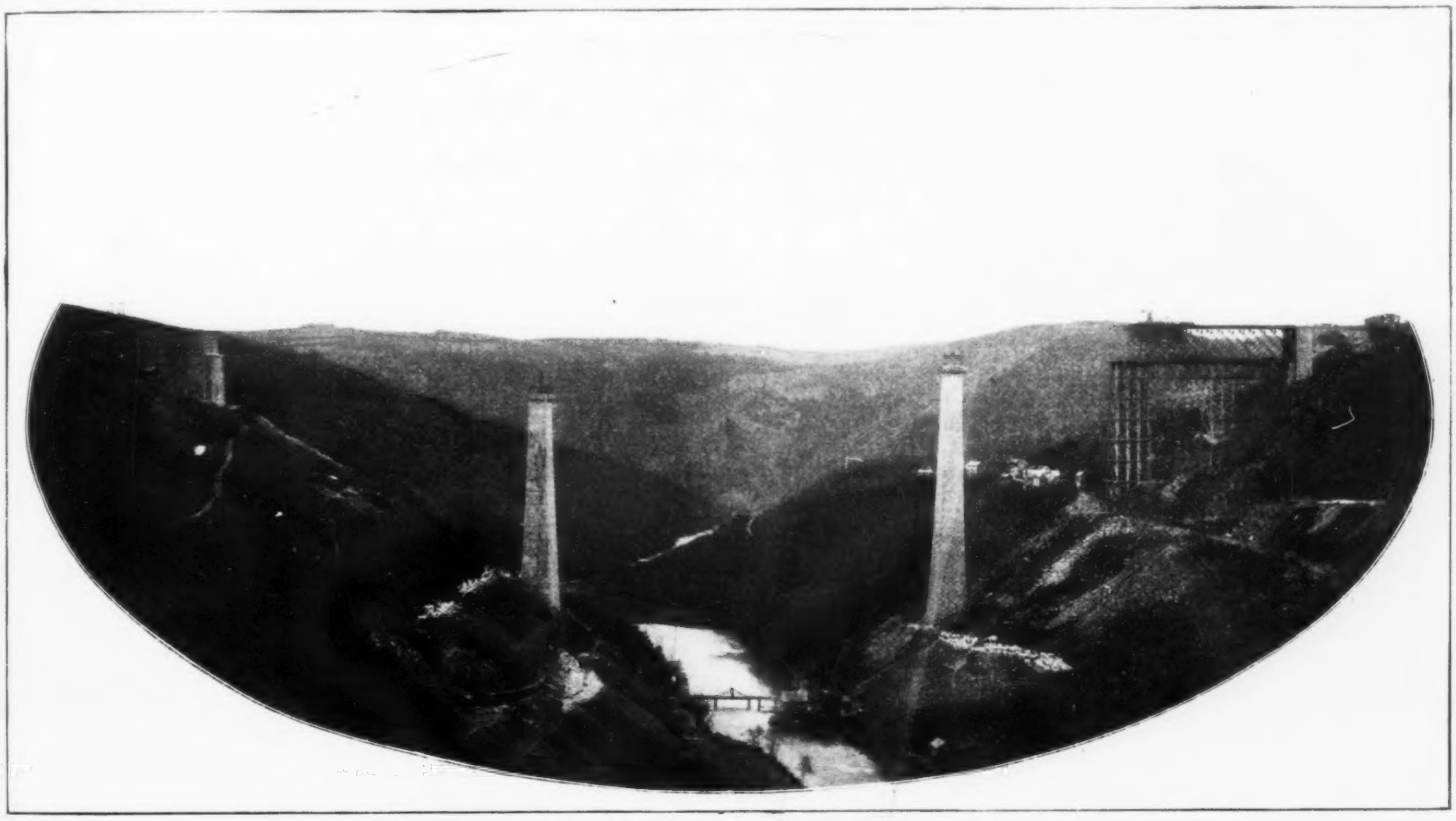
THE VIADUCT OF FADES.*

By Emile Guarini.

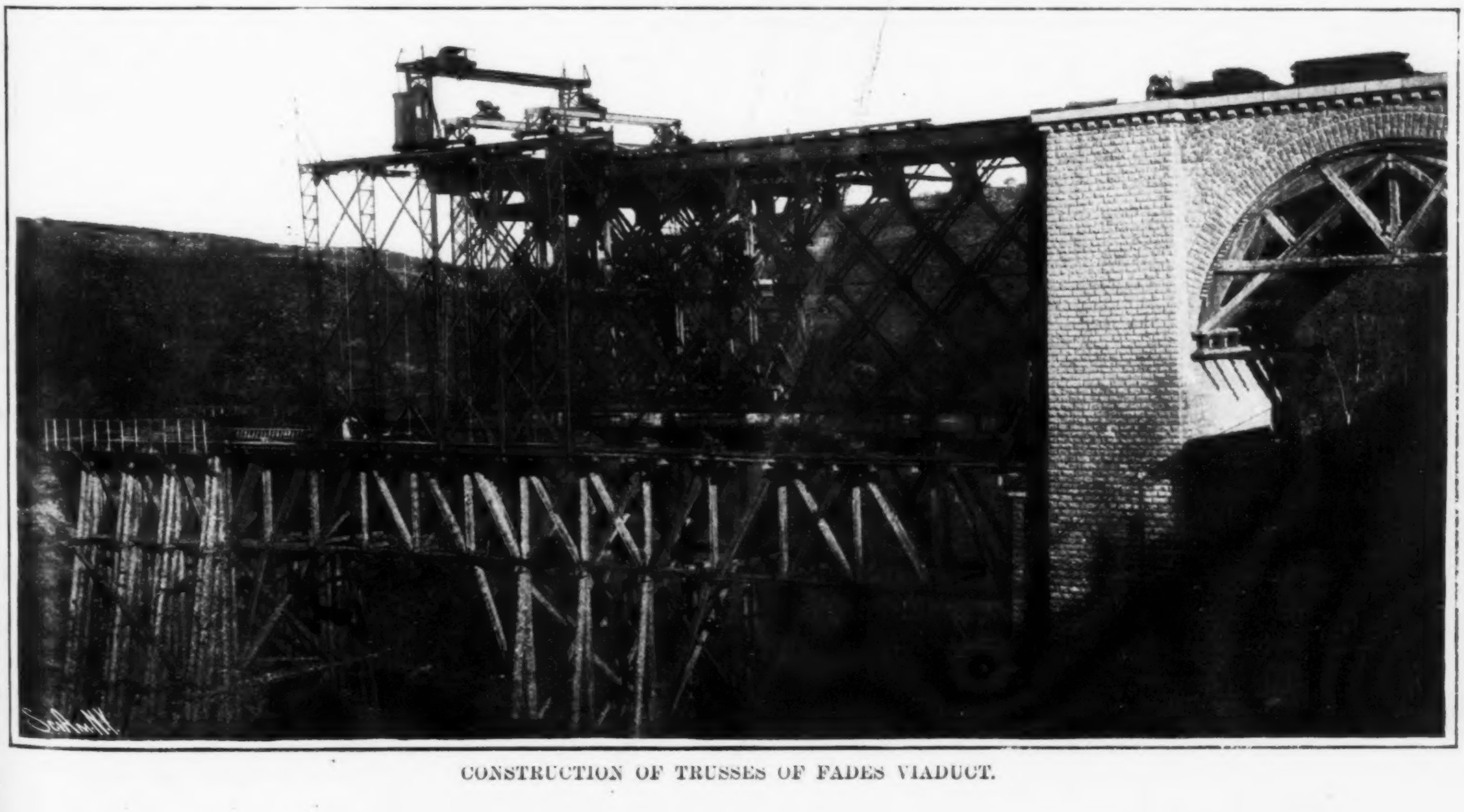
The Société Francaise de Constructions Mécaniques of Douai is at present constructing over the Sioule an immense viaduct designed to complete the railway lines of Tulle-Clermont and Montluçon-Gannat, the concession for which was obtained by it in 1901. The elaboration of the project of this great work gave rise to long and laborious studies. A ministerial decision approving the project of M. Draux, government engineer, ordered the construction of a viaduct 1,231 feet in length and 434 in width, but the difficulties in the way of the construction for a long time retarded the adoption of a definitive solution of the question, and some new exigencies that came to light during the course of the examination of the various projects and plans resulted in another delay in the finishing of the above mentioned line, the exploitation of which had been awarded to the Orleans Company.

We are indebted to the kindness of M. Virard, government engineer, for the possibility of laying before the eyes of our readers some of the aspects of the

* Specially prepared for the Scientific American Supplement.



THE GREAT VIADUCT OF FADES IN COURSE OF CONSTRUCTION.



CONSTRUCTION OF TRUSSES OF FADES VIADUCT.

great viaduct, which is certainly most remarkable by reason of its dimensions and the original character of its arrangements.

Its total length is 1,446 feet, out of which 1,231 are for the metallic part. The rails are situated at an altitude of 1,891 feet, say at 434.6 feet from the navigable channel. This exceeds by 8.2 feet the height of the viaduct that has hitherto been considered the highest in the world, and which was constructed fourteen centuries ago at Spoleto (in Umbria) for Theodoric. This viaduct, of which the height is therefore 426.4 feet, is entirely of stone.

The viaduct of Fades is constructed in such a way as to render it capable of withstanding loads under the most unfavorable circumstances, that is to say whatever be the force of the wind. When the action of this is combined with the stress resulting from the stoppage of a train on the viaduct, the piers of the latter undergo a pressure that does not exceed 205 pounds to the square inch at the level of the base of the foundation.

The total length of the superstructure will, as we have said, be 1,231 feet, with a width of 22¼ feet between the axes of the shore girders. There are two shore girders, which, at their upper part, support the bridge pieces that form with them the superstructure. This latter is supported by string pieces spaced 29 inches apart; and I-irons, very close together, support corrugated iron plate 2.3 inches in thickness. This arrangement is designed to allow the superstructure to resist, without deformation, the weight of a derailed engine.

It is scarcely necessary to say that the selection of the materials for the construction of a bridge of this kind is a matter of the greatest importance; and so the materials employed in this case for the masonry work especially are of the very best quality. For the preparation of the cement, granitic sand from the waste heaps of the neighboring quarries is used. This material, which is inexpensive, is brayed mechanically, washed with river water, and then tempered with water to form a mortar, which after it has set for 340 days, resists a pressure of 2,860 pounds to the square inch. The cost of it is much lower than would have been that of puzzolana, of which no deposit exists within less than twelve miles of the place.

The quarries, too, in the immediate proximity of the viaduct afford a granite of which the resistance is 7,865 pounds to the square inch, with cubes 2 inches square. Finally, the quarries of Lavadona, at a distance of 6¾ miles, furnished the dressed stone and rubble of granite, of a resistance of 8,480 pounds to the square inch, that served for all the facings. Dressed granite was employed for all the plinths, modillions, and parapets, as well as for the copings and stairs. The filling-in was done with rubble.

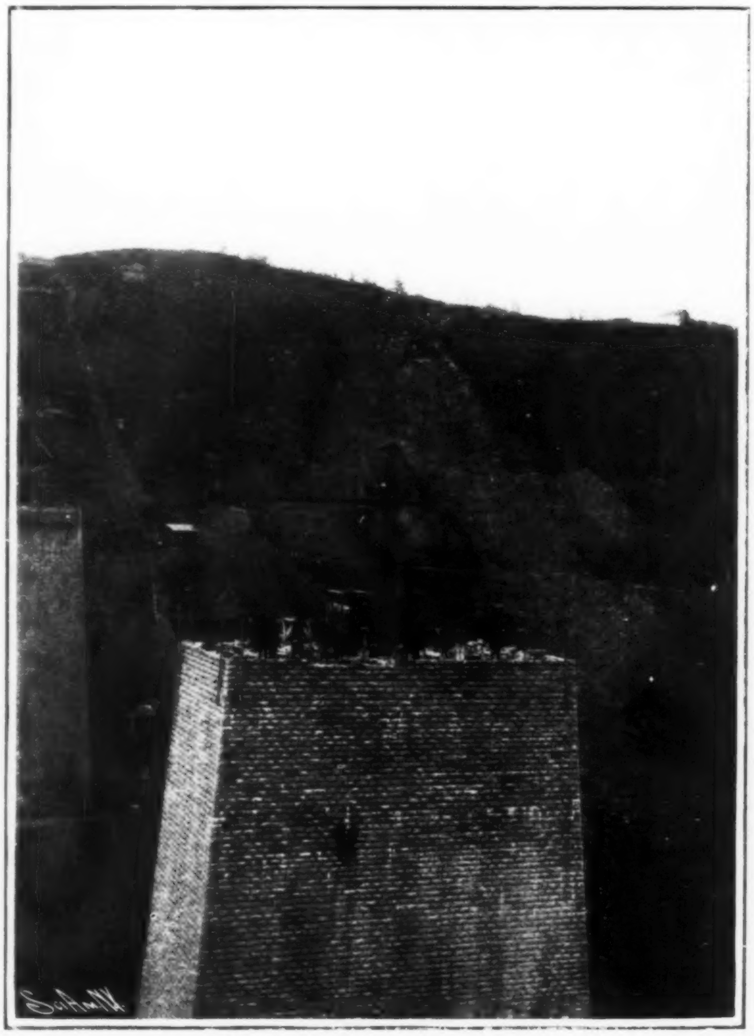
There are two masonry piers and abutments, which divide the superstructure into three spans, two shore ones of 378 feet each, and a central one of 472. The piers support a load of 1,679,524 pounds, and the abutments one of 592,332.

The copings, which are of dressed stone, are ornamented with brackets and astragals and project 36 inches from the wall of the masonry of the columns. Bronze cramps, 2 inches square, connect the blocks of stone that constitute the copings.

For the reason indicated above, the bolts of the bearing pieces of the pier to the right are arranged in a special manner, they being inserted in an anchorage of I-irons, which are imbedded in the concrete of the masonry.

The shore girders rest upon the abutments and one of the piers through the intermedium of steel apparatus designed to permit of expansion. These apparatus, which are fixed upon the abutments, consist of two cylinders 2 inches in diameter and 44 in length. Four circular sectors 2 inches in diameter and 52 in length constitute the movable bearings upon the pier. The height of the masonry piers, say 302.8 feet, which had never before been reached, evoked some serious objections based upon the fear that oscillations might be produced therein by the wind as in the case of lighthouses, factory chimneys, etc. But it is possible to balance the stress of the wind, which may be calculated in fact, and which is exerted in a known direction. Moreover, as the girder rests upon the piers and abutments, the piers constitute with the latter a combination to which the superstructure gives all the rigidity desirable.

LOOKING THROUGH THE TRUSSES.



HEAD OF THE PIER ON LEFT BANK.

THE VIADUCT OF FADES.

Upon the bridge pieces are mounted the wooden flooring of the superstructure and the sleepers for the rails. The whole is rendered compact and rigid by cross stays and wind braces. The sleepers, which are of wood, are securely bolted to the bridge pieces and concur in giving strength to the superstructure. In case of derailment, in fact, they would hold the locomotive and cars in the median part, and therefore serve as guides.

Each of the girders is formed of two chords that support a sole 40 inches in width and in two parts of 20 inches, which are one inch distant from each other. These soles are composed of half-inch plates that vary in number from one to four according to the resistance that the girder has to offer. The webs are formed of one or two plates half an inch in thickness. As for the chords, they are naturally parallel, and are spaced 20 inches apart.

A space of 12 inches is left between the extremities and the face of the abutments in order to permit of expansion.

At the upper part of the superstructure will be established an iron service bridge to permit of the surveillance and maintenance of the bridge.

The abutment to the right is a semicircular arch. Its length is 78.75 feet, and its fore part, which is 6½ feet in width by 29½ in length, forms the support of the right-shore end of the superstructure. These dimensions are likewise those of the fore part of the left abutment, which latter is 32 feet in width, between parapets, by 134 in length. It has two semi-circular arches. The thickness at the key is 36 inches, and the opening is 46 feet. There is an intermediate arch abutment of 9 feet at the springings. One of the abutments is 28½ feet in height from the foundation to the springings of the arch, while the other has the same thickness, but is higher, say 77¾ feet. The piers rise to a height of 302.8 feet above the foundations and are provided with parabolic facings. Above the foundations they measure 38 and 72 feet, and under the cap 18 and 36 feet. They comprise a crown of 10 feet. Their section is rectangular with rounded corners. The width of the small faces remains constant (6½ feet). Two openings united by a semi-circular vault serve for the mounting of the materials. The thickness is 15¾ and 6 feet on the small faces, and 21 and 12 on the large ones. It is the pier of the right-hand shore that will support the fixed bearing of the girder, and the effects of expansion will therefore be transmitted on one side and the other of this pier.

After the question of the piers arose that of the putting of the right girder in place, and which was complicated by the fact that in order to do duty for the basin of the Bouble, the Orleans Company had to employ two-axled coal cars of 20 tons capacity.

It will perhaps prove of interest to give here a brief description of the method of constructing the superstructure, the placing of which will offer, as may be imagined, many peculiar difficulties.

Two frameworks 100 and 130 feet in height, connected by girders of 71½ and 59 foot span, will constitute a wooden scaffolding that will serve for the mounting. This will occupy half a shore span, say about 190 feet. Beyond, the superstructure will be continued projectingly, in the first place as far as to the neighboring pier (after, of course, having been balanced by means of a 200-ton counterpoise placed near the abutment and distributed over a length of 30 or more feet), and then as far as to the axis of the central span. For this purpose, there will be utilized a cage that will roll over the finished part of the superstructure. Compressed-air machines will be employed for the riveting, unless it becomes necessary to perform the work by hand. The cage will move forward by one panel of 25 feet in measure as the mounting proceeds.

The same operation will be performed on both halves of the superstructure, which will be joined in the cen-

r by causing the extremities to coincide. Hydraulic jacks will be used for this purpose. The bearings upon the abutments will be lowered at the same time. The mass manipulated may be estimated at about 70 tons of cast steel, 1,800 of rolled steel, and 475 tons of rolled iron. The quantity of filling for excavations and foundations reaches 282,400 cubic feet, and the masonry work comprises more than 953,000 cubic feet of ordinary rubble, 140,000 of scabbled stone, and 15,750 of dressed stone.

The work is a very important one and by far exceeds the remarkable ones of Garabit and Viar, and moreover, is differentiated from those viaducts by improvements which, while reducing the general cost, have increased the strength of the structure.

ARTIFICIAL CENTERS OF POWER.

One of the most important openings for future engineering enterprises is the establishment of large power centers, not only where water power is available, but where fuel is abundant as well.

Take, for example, the vast coal mines in the vicinity of the city of Philadelphia and those in the vicinity of St. Louis. In each case the power for industrial establishments and all kinds of moving machinery, large and small, in use in the city, including the street cars and the rolling stock on all roads, can well be furnished by electrical currents from large generating establishments near the mines. Add to the above the establishment of gas works sufficiently large to furnish all the gas needed for illumination, for gas engines, for heating and cooking purposes in a great city. In the case of St. Louis those gas works should be near the extensive coal mines of Belleville, and other coal-producing regions only a few miles from the city.

The effect of these two great steps forward upon the physical and sociological characteristics of a city can hardly be over-estimated. The ultimate economy and convenience of such installations are enough to justify them. We have yet to learn how cheaply fuel gas and electric currents can be furnished to large concentrated groups of consumers. But omitting all questions of mere financial economy, what a saving in health, beauty, and enjoyment! The London fogs which we hear so much about are produced largely by London smoke, and the prevention of smoke will to a very great extent be the prevention of the fog. I look forward to the day when, instead of a small volcano of smoke from a brick crater above every house, St. Louis will have all its heating and cooking done by gas, and all power will be furnished by electric currents, or by gas and combustion engines, both gas and electricity coming from the gas works and power plants at the mouths of the coal mines in Illinois. What an era of cleanliness and comfort this presages! This era of cleanliness will be brought about by the engineers. Hence engineering education must see to it that engineering students are prepared for their high mission. The proposed "Million Club" of St. Louis bears no comparison with a possible "Clear Sky Club." The former proposes to seduce 250,000 non-resident smoke-makers into joining the 750,000 smoke-makers already resident in St. Louis, thereby making smoke enough to shut out the sun entirely (they almost did it during a whole week last November). The "Clear Sky Club," on the other hand, will propose to eliminate all smokers by sending coal-burning power plants to the mines, thereby leaving the city so clean and beautiful that 250,000 lovers of pure air, clear skies and godliness will seek homes among us of their own accord. The elimination of smoke, soot, and ashes will make St. Louis absolutely bright and clean, and similar improvements here would go far toward producing the same beneficial results in the city of Philadelphia. Already our cities have, or are making arrangements for, an abundant supply of pure water. This has been and still is a great branch of engineering, and it deserves an important place in our schools of engineering. We must next provide pure air and a clear sky.

These steps forward involve no very great addition to our engineering knowledge, but they give opportunity for engineering enterprises, and they show most clearly how essential co-operation is in such work. Large power plants and extensive gas works require much private capital, unless we fly to the extreme of public ownership. The economic construction of large power plants and gas plants; the laying of pipe lines and an unprecedented amount of electric cables, all or nearly all underground, constitute a great field and furnish great engineering opportunity.—C. M. Woodward in a paper read at St. Louis.

COMBUSTION ENGINES.

In the words of C. M. Woodward, "the clumsy steam engine, with its wasteful furnace, its huge boiler and chimney, is doomed. It has done great work in producing available energy and in wasting still more. It has played a most important part in modern civilization, and it deserves well at our hands, but nothing can stay the decree of progress. Sentence will soon be pronounced, but the day of execution has not been set. I never expect to see the day when steam power plants will cease to exist, but my children will see such a day.

"Think for a moment of the present complicated, indirect method of procedure for converting the energy stored in coal into mechanical energy in a moving piston or a revolving shaft. Coal and air are fed into a furnace where combustion converts them into great volumes of a mixture of hot gases. The greater part of the heat and all the volume of these gases escape through the chimney, a small part of the heat only is drawn off by the steel shell and tubes of a boiler and transmitted to a body of water, which is thereby transformed into steam. The steady generation of steam against high pressure, added to its expansion as the pressure is reduced, enables it, when conducted to a cylinder, to drive a piston or revolve a shaft, thereby producing mechanical power. The clumsiness of the operation is equaled only by its wastefulness, which varies from 88 per cent to 95 per cent.

"The problem to-day is: 'What is the most direct and most economical road from coal to moving machinery? Engineers are attacking this problem on all sides, and attacking it successfully; gas engines and combustion engines of various sorts bear witness. The future prime mover will burn (not explode) its fuel in the working cylinder, and the piston will be driven, first by the products of combustion as their volume increases, and secondly by their expansion against a diminishing resistance. I predict great things of the Diesel motor. Originally it was designed to burn powdered coal mixed with hot compressed air; but crude petroleum was found to be preferable. So long as oil flows abundantly from wells, oil will generally be used, but powdered fuel, native or prepared, will doubtless prevail ultimately. The economy and directness of the combustion motor cannot be excelled, and when a few years of study and experiment have been applied to the work of simplifying the mechanism (it was a century from James Watt to a triple-expansion Corliss), we may expect it to come into general use for all great central power stations.

"The vitality of the steam engine is due to-day to the mechanical perfection of its design. Its simplicity is marvelous. It is started and stopped with the greatest ease and it almost takes care of itself. The invention of the steam turbine has probably given to the furnace and steam boiler another lease of life. The wonderful adaptability of the turbine for electric generators is something which was not anticipated.

"Will not someone design and construct a combustion engine which shall consume continuously oil and compressed air, thus maintaining a high pressure in a gas chest and driving a turbine with the products of the combustion used expansively as is now done with steam? The proposition is an attractive one, both for the lecture room and for the engineering laboratory. It is sufficient now to call attention to its possibility, and to indicate a point for study and progress.

"It will not be amiss for me to quote the figures given me by the engineer in charge of the Diesel engines which drove the generators for power and light in the 'Tyrolean Alps' at the late world's fair in St. Louis.

"These engines, three in number, of 225 horse-power each, were the observed of many observing engineers during the seven months of the fair. The assistant engineer in charge kept daily records of the work done, and fuel used, and kindly gave me a sample of his reports. The details are extremely interesting. The work was measured at the switchboard, no allowance being made for loss of energy in the engine, air pump and generator. The total work of the three engines between noon and midnight was 2,768.5 kilowatt hours. This is equivalent to 3,711 horse-power hours.

"Total fuel used (Indiana oil), 266 gallons.

"Fuel per 100 kilowatt hours, 9.58 gallons.

"Fuel cost in car-tank lots, 3 cents per gallon.

"Cost per 100 kilowatt hours, $0.287.

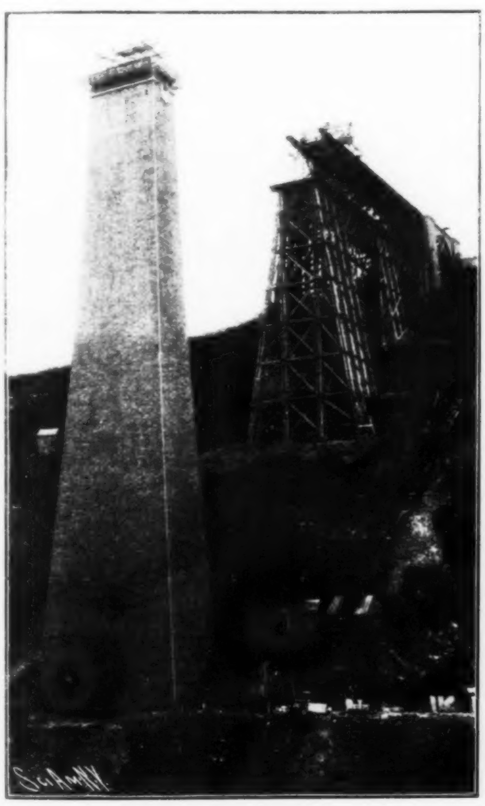
"Cost of the day's fuel, $7.98, or 2.15 mills per horse-power hour.

"Thus one cent paid for the fuel for one horse-power for four hours, forty minutes.

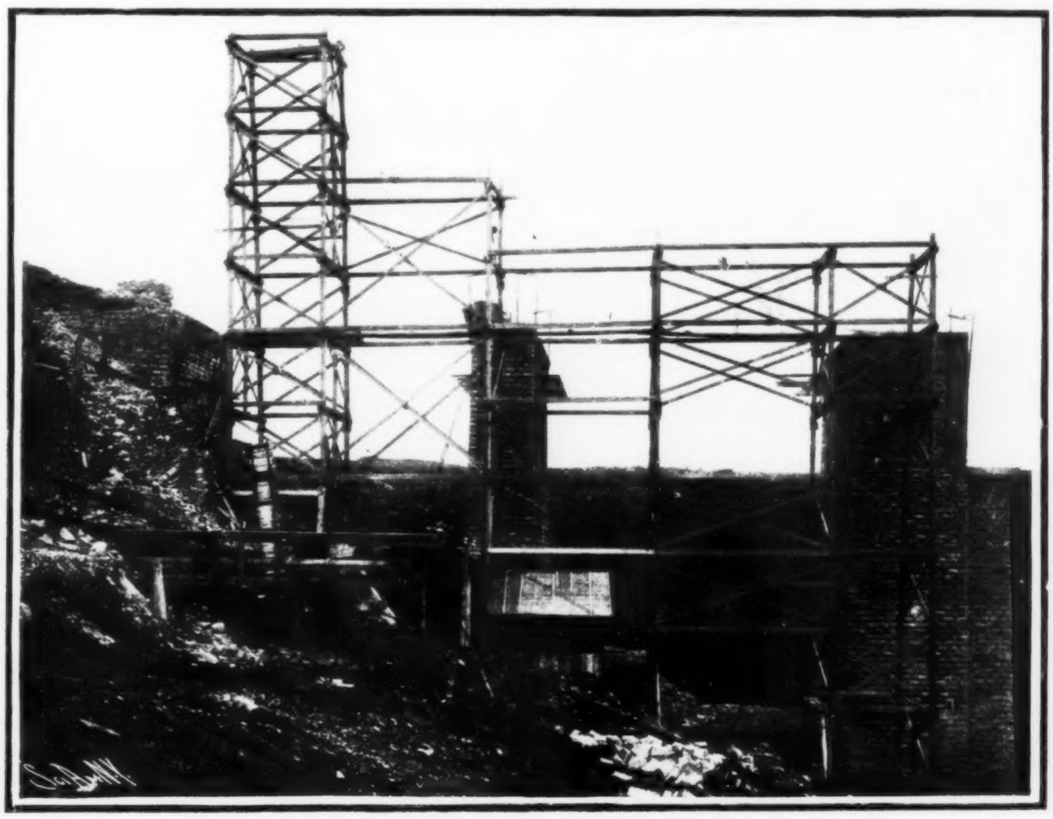
"The three engines worked under about two-thirds of a full load and used three gallons of lubricating oil during the day.

"The above figures seem to me remarkable.

"While still wasteful, as nature measures energy, these engines are several times as efficient as the better styles of ordinary steam engines. Doubtless they lack simplicity and the certainty of action which comes from experience and close study; but I cannot help feeling that the road to the future 'prime mover' runs hard by the construction shops of an internal-combustion engine. Let students and professors take warning."



PIER AND ABUTMENT OF RIGHT SHORE.



LEFT SHORE ABUTMENT OF THE VIADUCT.

THE VIADUCT OF FADES.

THE SPARK COIL.

The spark coil as used on gasoline cars with jump-spark ignition is a simple-looking, oblong hardwood box, with a magnetic trembler or buzzer on one end, and the necessary binding screws to connect the wires to. It is certainly a very important part of the power mechanism, somewhat delicate, and frequently in need of attention, but very few are the drivers who thoroughly understand the principles of its operation. The literature issued by the coil manufacturers as a rule contains nothing from which the beginner might learn anything about coils, and for those beginners who wish

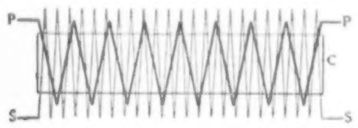


DIAGRAM OF SPARK COIL.

to get an insight into the *modus operandi* of this device an attempt will be made here to make the subject clear.

Before we begin the description of the coil, it will be advisable to first briefly refer to the phenomenon of electromagnetic induction upon which the spark depends, and to the nature of the two kinds of spark—the contact spark and the jump spark.

A SOURCE OF CURRENT REQUIRED.

It will be understood, of course, that to produce an electric spark we must, first of all, have a source of electric current, which may be a battery of dry cells, of wet cells, or of storage cells, a dynamo or a magneto generator. Every source of electric current has two terminals or poles, and in order that a current may be produced, these terminals must be connected to each other by a continuous conductor, say a metallic wire. If the conductor is interrupted or broken at any point along its length, the current ceases to flow. The path of flow of current is called its circuit.

A current flowing in a conductor is endowed with a property similar to that of the inertia of moving bodies, and may for practical purposes be regarded as possessing inertia. When a person rides in a vehicle at a good speed, and the speed is suddenly reduced, as by applying the brakes, he is thrown forward from the seat, owing to his inertia. Similarly, when the speed is suddenly increased, as by throwing in a "fierce" or quick gripping clutch on an automobile, or whipping up a horse, the occupants of the vehicle are thrown back against the seat, owing to their inertia. Inertia is defined to be that property of matter by virtue of which it tends to persist in its state of rest or motion (or opposes changes in its state of rest or motion). An electric current also possesses a property by virtue of which it opposes changes in its rate of flow, both increases and decreases.

When a circuit in which a current flows is broken, the current, as already pointed out, ceases, but owing to its inertia it does not cease instantaneously, but is literally carried across the gap at the break, the same as a person in a suddenly stopping vehicle is carried from his seat. A current thus carried across an air gap forms an electric spark.

INDUCTANCE.

In electric science the term "inertia" is not used however; it is more convenient to associate the property here described with the circuit than with the current. The same idea which we here attempt to convey by saying an electric current has inertia, is conveyed by the electrician by saying the circuit has self-inductance. That a circuit or a conductor has self-inductance, then, means that it possesses a property by virtue of which it opposes variations in the strength of current flowing through it. It will now be seen that a spark may be produced by connecting a source of current to a circuit of great self-inductance, and then breaking or interrupting the circuit at some point. Owing to the self-inductance of the circuit the current will continue to flow for a short time after the circuit is broken; in other words, a spark will be produced. The problem then is to produce a circuit of large self-inductance.

The self-inductance of a conductor depends upon its length, the manner in which it is arranged, and upon the surrounding medium. With a straight conductor it is proportional to the length, but the inductance of this same conductor may be increased by winding the latter up in a coil, and may be still further increased by inserting a core of soft iron wire into the coil. Consequently, a coil of insulated wire wound over a core of soft iron wire has a comparatively large self-inductance, and if such a coil is connected to a source of current, say a battery, and the connection is broken, the current will persist in flowing for a short time after the break has occurred, and a spark will thus be produced at the point of the break in the circuit.

NATURE OF CONTACT SPARK.

Air offers an enormous resistance to the passage of an electric discharge or spark, and it is figured that an electric pressure of 10,000 volts is required to make a spark jump a gap of 1-16 inch in the atmosphere, while the ordinary ignition battery of four dry cells has a pressure of only six volts. But if the spark terminals are first brought in contact and then separated while an electric current is passed through them, a sufficiently hot spark may be produced with only the limited pressure of the small dry battery. However, at the moment the spark occurs the pressure acting in the circuit is greatly increased over that of the battery, by the effects of the self-inductance of the circuit. As soon as the mechanical pressure between the two points in contact is removed, and the points begin to separate, the electrical resistance at this point is greatly increased, which results in the production of considerable heat. This heat raises the contact points to such a high temperature that a little of the metal of the contacts is vaporized, filling the intervening space between the contact points, and forming a gaseous conductor of comparatively little resistance between the points after they are separated. Thus a current is allowed to flow across the gap, for a short time after the points have been separated, and the circuit has been broken, constituting a spark. What one sees when the spark occurs is the red-hot particles of metal, not "electricity" as many suppose. This kind of spark is known as the "contact spark," and is used to some extent for ignition purposes.

However, the type of spark with which we have more particularly to do here is the jump spark, which passes between spark points remaining permanently at a certain distance from each other, from 1-32 to 1-16 of an inch. To obtain a spark under such conditions, it is obviously necessary to produce a very high electric pressure in some way. It was stated above that about 10,000 volts are required to cause a spark to jump across a gap of 1-16 inch in the atmosphere; but it is found that in the compression chamber of an engine, where the pressure at the time the spark is wanted, that is, at the end of compression stroke, is from 60 to 100 pounds per square inch above atmosphere, an electric pressure from five to eight times as great is required to produce a spark. Consequently, if the spark points be about 1-16 inch apart, 50,000 to 80,000 volts must in some way be produced from the five to six volts which the dry battery or other source of current places at our disposal. This is accomplished by means of the jump spark coil or induction coil, the action of which is based upon the phenomenon of mutual induction.

MUTUAL INDUCTION.

Suppose two electric circuits, say in the form of spools or coils, to be located side by side, the one including a source of electric current and the other none. If the circuit containing the source of electric current is alternately opened and closed, it will be found that every time it is either opened or closed an electric impulse or momentary current is produced in the other circuit, although it has absolutely no metallic connection with the former. This effect is due to mutual induction between the two circuits. The circuit containing the source of current is called the primary circuit, and the other the secondary circuit. When the primary circuit is broken, the current induced in the secondary circuit flows in the same direction as the current in the primary circuit, but when the primary is closed again, the current induced in the secondary circuit is in the opposite direction. The inductive effect lasts only while the current in the primary winding varies in strength, and no matter how strong a current may flow in the primary winding, if it does not either increase or decrease in value, there is no induced electric impulse in the secondary. The pressure of the electric impulse induced in the secondary coil depends upon the rate of variation of the current in the primary circuit, the ratio of the number of turns in the secondary coil to the number of turns in the primary coil, upon the proximity of the two coils, and upon the medium surrounding the coils. In order to produce a very strong electric pressure in the secondary coil, the latter must consist of a very large number of turns, while the primary has only few; the flow of current in the primary must be stopped or started as quickly as possible; the two coils must be located close together, and a core of soft iron wire must be passed through the coils.

NECESSITY OF THOROUGH INSULATION.

With the high pressures obtaining in ignition work, great care must necessarily be bestowed upon the insulation of the coil. The primary winding must be thoroughly insulated from the secondary winding, and both must be insulated from the core. Only the best insulating materials should be used in insulating a coil. The following is the usual method of construction of a coil.

The core is made of thin, specially annealed iron wires cut to exactly the same length. It is usually about three-quarters inch in diameter. Over the core is slipped a tube of hard rubber, for insulating purposes, and over this are wound two or more layers

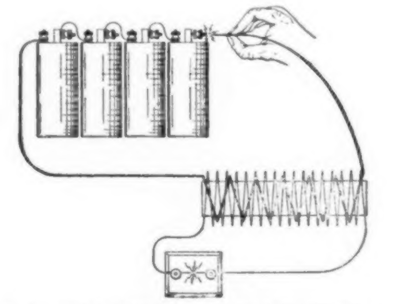


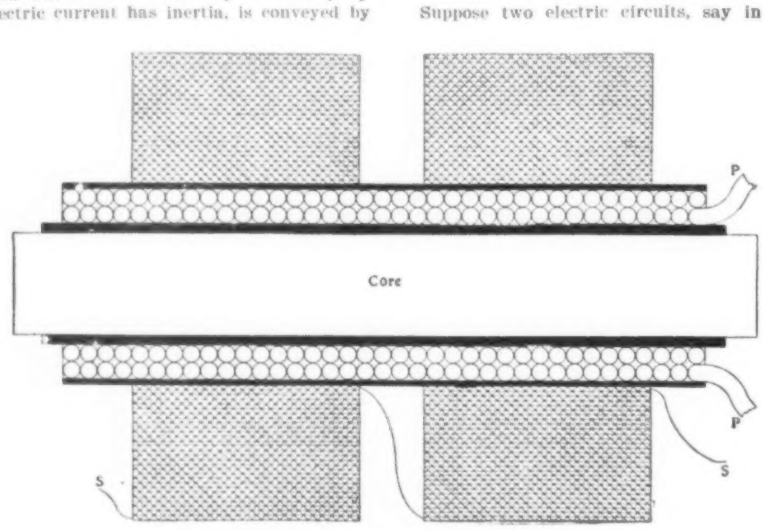
FIG. 1.—PRODUCING A SPARK WITH AN INDUCTION COIL.

of primary wire. This may be of No. 14 to 16 gage, and insulated with cotton. Over this is wound a layer of insulation, and over that the secondary winding. The secondary winding consists of very fine silk insulated copper wire, and the succeeding layers are further insulated from each other by a layer of paraffined paper. The secondary winding is usually wound on two or more spools, at some distance from each other along the length of the coil, these spools being connected in series; that is, the end of one spool is connected to the beginning of the adjacent spool. In this way, the inductive effect obtained is the same as if the whole secondary winding was wound in one spool, but the voltage between successive layers in each spool is less, and there is consequently less strain on the insulation. Practically speaking, each turn or convolution of the secondary winding has a certain pressure induced in it, and the pressure of all the turns is added together. Consequently, the stress on the insulation between successive layers is the greatest between the first turn of one layer and the last turn of the next layer, and depends upon the number of turns between these first and last turns respectively. Now, evidently this number of turns is smaller when the layers extend only one-half or one-third the length of the coil than when they extend one whole length. The stress on the insulation between layers is practically halved by winding the coil in two spools, for instance, and connecting these in series.

With a coil constructed as described, a jump spark may be produced, for demonstrating purposes, as follows (Fig. 1): Connect the leads of the secondary winding to fixed insulators and bend the ends so they are 1-16 to 1-8 inch apart. Connect one lead of the primary winding to an electric battery, and with the other lead of the primary winding brush against the other terminal of the battery, as indicated. When the contact is broken there will be a spark both at the point of rupture in the primary circuit and at the gap in the secondary circuit. An electric impulse is also induced in the secondary circuit when the contact in the primary circuit is established, but this impulse is too feeble to cause a spark to jump across the gap. Only the impulse induced in the secondary when the primary circuit is broken is practically available for sparking purposes.

THE VIBRATOR.

In the practical use of a coil we require a device which performs the function corresponding to the brushing of the primary lead against the battery terminal by hand in the above described experiment, that is, rapidly making and breaking the primary circuit. This is usually accomplished by means of a



SECTIONAL VIEW OF SPARK COIL.

magnetic vibrator, the action of which will be explained with reference to Fig. 2.

This figure represents an end view and a side view of a complete coil, the side view being shown partly in section, and the winding only indicated diagrammatically. In the figure, A represents the soft iron wire core upon which are wound the primary and secondary windings, indicated by heavy and light zig-zag lines respectively. The two leads of the secondary winding are connected to two binding posts on top of the case, S_1 and S_2 respectively. One lead of the primary winding is connected to the binding post, P_2, on the end of the case, and the other lead to a metal block, B, secured to the end of the case. To this metal block is screwed a flat steel spring, C, having riveted to its outer end a small cylindrical block of soft iron, D, called the armature. This armature, D, is located exactly opposite the end of the soft iron wire core, A, and is normally held at a little distance from the core by the steel spring, C. The steel spring, C, is spanned by a brass yoke, E, secured to the end of the coil box by means of screws. This yoke is drilled and tapped at its center to receive the contact screw, F, which can be adjusted in it and locked in adjustment by the check nut, F_1. The point of the contact screw is usually tipped with hard platinum (or platinum-iridium alloy), and a similar contact point is fastened to the contact spring opposite the point of the contact screw. The two contact points are normally pressed together by the spring, C. The yoke, E, is connected to the primary binding post P_1 by a wire.

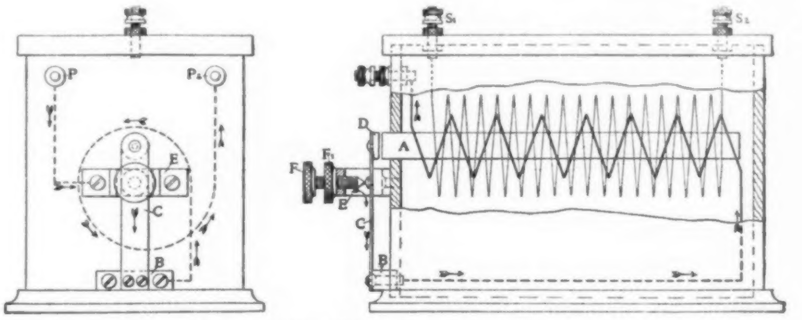


Fig. 2.—END ELEVATION AND SIDE ELEVATION OF SPARK COIL.

Now suppose a battery to be connected to the two posts P_1 and P_2. The positive or carbon terminal of the battery may be considered to be connected to P_1, in which case the current will enter at this terminal. As indicated by arrows, it will flow through the wire connection to the yoke, E, through the contact screw, F, across the contact at the points to the contact spring, C, to the metal block, B, through the primary winding of the coil to the binding post P_2, and from there back to the battery. As soon as the current begins to flow through the primary winding of the coil, it magnetizes the soft iron wire core, A, and the latter attracts the armature, D, and the outer end of the spring, C, thereby drawing the contact point on the spring away from the point of the contact screw, F, and interrupting the primary circuit. The flow of current through the primary winding is thereby stopped, and an electric impulse induced in the secondary winding, and if the terminals of the latter are sufficiently close together, a spark will jump across the gap.

As soon as the current in the primary winding ceases, the core, A, loses its magnetism, and the armature, D, and spring, C, are returned to their original positions by the spring force of C, and contact is established again between the platinum point on the spring, C, and the point of the contact screw, F. The current then flows again through the primary winding, the armature, D, is again attracted, and the circuit broken at the contact points, which gives another spark in the secondary. This process, or cycle, requires only an extremely short time, less than 100th part of a second, and is repeated indefinitely as long as the source of current is connected to the primary binding posts, P_1 and P_2. The rapidity of the break

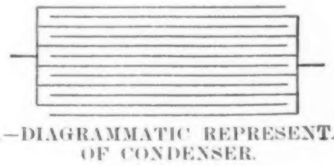


Fig. 3.—DIAGRAMMATIC REPRESENTATION OF CONDENSER.

and of the vibration of the spring, C, can be varied by adjusting the contact screw, F.

By varying the adjustment of the contact screw, not only is the number of sparks in a given time varied, but also the strength of the individual sparks. Suppose, for instance, that the contact screw, F, is screwed so far out that the spring, C, merely bears against the point of the contact screw when at rest. Only the slightest force is then required to draw it away from the point of the screw, and the circuit is broken as soon as the current begins to flow in the primary and long before it reaches its maximum value. But if the current in the primary winding only attains to a small value, the inductive effect in the secondary can only be small, and only a small spark is produced.

The magnetic circuit-breaking device here described is variously called a vibrator, buzzer, or trembler. In some coils the block, D, is not used, the attraction of the core, A, on the steel spring, C, being depended on. Platinum and platinum-iridium alloy are used for the contact points because these are less affected by heat than any other metallic conducting material, hence are not readily burned away or oxidized over their surface and rendered non-conductive.

THE CONDENSER.

With a coil as used in the experiment illustrated in Fig. 1, and also with the coil in Fig. 2, a number of difficulties are encountered. It will be found that the spark produced at the break in the primary circuit (at the vibrator points) is larger than the spark at the gap in the secondary circuit, and the latter with a coil of the ordinary dimensions would be too small to effect ignition. There is no need for a spark at the vibrator points, consequently the energy necessary to produce a spark at this point is wasted, and besides it results in rapid burning away of the platinum contact points.

It was shown that in order to produce a large spark at the gap in the secondary circuit, it is necessary that the current in the primary circuit die out very rapidly. On the other hand, it was also shown that the self-inductance of the primary winding opposes a rapid dying out of the current in that winding, and the spark at the break or contact points is a proof that the current in the primary circuit does not die out abruptly, but decreases gradually. The whole trouble

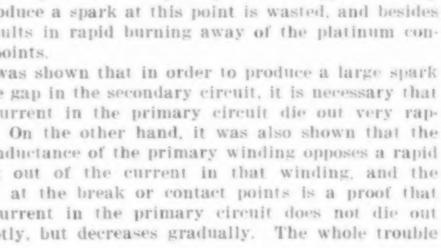


Fig. 4.—CONSTRUCTION OF CONDENSER.

is therefore due to the self-inductance of the primary winding, which tends to cause the current to continue to flow after the circuit is broken, thereby producing a spark at the primary contact points, and reducing the inductive effect in the secondary winding. The effect of the self-inductance of the primary winding must therefore be overcome in some manner, and this end is accomplished by means of an electric condenser.

An electric condenser is a device which will absorb or hold an electric charge in about the same manner as a jug holds a liquid. Every conductor of electricity forms a condenser, and its capacity for holding charge depends upon its surface. A condenser is therefore made of electrically conductive material formed into such shape as to present the greatest possible surface for the least amount of material. The usual method of constructing a high-tension electric condenser is as follows: The conducting material used is tinfoil, of which a large number of sheets are prepared, all cut to the same size. These are placed one on top of the other, with a thin sheet of insulating material,

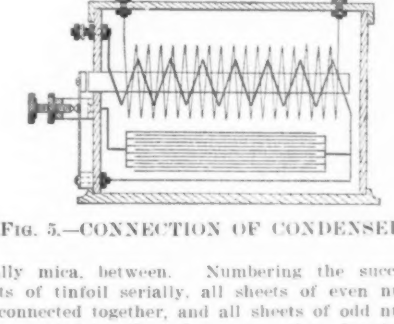


Fig. 5.—CONNECTION OF CONDENSER.

usually mica, between. Numbering the successive sheets of tinfoil serially, all sheets of even number are connected together, and all sheets of odd number are connected together, these connections forming the terminals of the condenser. The condenser is then connected across the vibrator, one terminal being connected to the block, B, in Fig. 2, and the other terminal to the yoke, E. The condenser is usually placed in the bottom of the coil box, below the coil proper, and the connections are all made inside, so that there is absolutely no external evidence of the presence of such a device, and we are sure many users of coils are not aware of the existence of the condenser.

The flow of current through the circuit after contact has been broken, and which is due to the self-inductance of the circuit, is called the extra current. With a condenser connected as shown in Fig. 5, the extra current flows into the condenser, and the spark at the contact points is almost entirely obviated. Of course, the condenser must be of such capacity as to just neutralize the inductance of the primary circuit. Capacity is, in fact, an "antidote" for self-inductance, and neutralizes all its effects. If the capacity just balances the self-inductance, the current in the primary will die down almost instantly, and consequently a high pressure will be induced in the secondary winding.

The self-inductance that must be neutralized by the capacity of the condenser is not only that of the primary winding of the coil, but that of the whole primary circuit. A battery of cells has no self-inductance, but a dynamo or magneto-generator has considerable self-inductance, and for this reason the ordinary spark coil designed for use with a battery usually gives poor results when used with a dynamo or magneto, because its condenser has not enough capacity for the combined self-inductance of the primary winding and the dynamo armature.

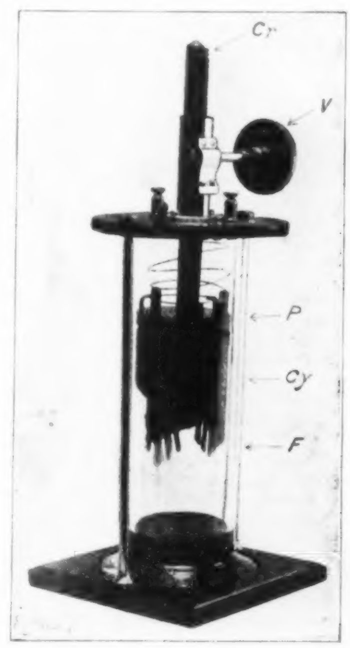
When the coil is wound and the condenser assembled, they are placed in the box, the wire connections are made, and the box is then filled with paraffine in the fluid state. Paraffine is a very good insulating material, and as it penetrates right into the coil, it materially improves the insulation. It also prevents moisture reaching the wire.

The secondary binding posts are usually located on the cover of the box, as far apart as possible, to prevent leakage between them over the surface of the box.—Horseless Age.

THE BERGONIE-VARRET LIQUID RHEOSTAT.

By Our Belgian Correspondent.

Prof. Bergonie's liquid rheostat, in the form in which it has recently been constructed by electrical



THE BERGONIE-VARRET LIQUID RHEOSTAT.

engineer Varret, of Paris, permits of varying from infinity to a minimum the resistance interposed between a galvanic or a faradic source and a subject treated by electricity. Such variation is absolutely gradual and allows of the substitution of this apparatus for all commutators or reducers of potential.

The electrodes of this rheostat are two concentric cylinders beveled off and terminating in a fringe of spun glass. The internal cylinder, which is provided with a metallic bottom, is screwed directly to the end of a rack. The external one is supported by a wide ebonite disk by means of rods at the side. This disk is kept at a constant distance from the internal cylinder by means of small pieces of ebonite secured in terminal apertures, so that the film of liquid that has a tendency to establish itself from one pole to the other shall be as resistant as possible. In reality, since there is no reason why the insulating platform should dip into the water, the loss of insulation as a result of electrolysis no longer exists. The external cylinder is in constant contact with the corresponding terminal of the apparatus either through a sliding rod or a spiral spring that expands or contracts according to the motions of the rack, Cr. This latter, which is actuated by the handwheel V, moves the insulating platform, P, carrying the double-cylinder plunger, Cy, the lower ends of which are provided with fringes of glass.

After the glass receptacle has been about half filled with water, and the plunger has been made to descend, a contact is established between the glass fringe and the liquid. The resistance introduced corresponds then to that of the thin film of water that establishes itself through capillarity between the liquid of the receptacle and the plunger. In measure as the latter descends, the glass threads in contact become more nu-

merous and shorter, and then the two cylindrical surfaces cut to a bevel come into contact through a progressively increasing surface.

The initial resistance is 600,000 ohms, and the final about 150, with pure water. The perfect insulation between the two electrodes is very appreciable, since it completely prevents any of those short circuits that occurred in the long run in the old models, and thus reduced the initial resistance to such an extent as to prove detrimental in delicate applications. Since electrolyzation of the insulator is impossible, the apparatus has practically an unlimited life.

[Continued from Supplement No. 1521, page 24374.]

METEOROLOGY IN THE BRITISH EMPIRE.*

By Sir John Eliot, K.C.I.E., M.A., F.R.S.

The previous statement of the meteorology of India has indicated the chief conditions which affect the crop returns seriously or disastrously over large areas in India. They may be summed up briefly as follows:

(a) The dry monsoon. Absence or unusual feebleness of cold-weather storms.

(b) The wet monsoon. General feebleness of the monsoon current, due either to corresponding feebleness of the southeast trades, or to unusual diversion to East Africa; or local feebleness in a part of India, due to local conditions, or to abnormal diversion to other rainfall areas in South Asia. These conditions give rise in the areas affected to one or more of the following features:

(1) Prolonged delay in the commencement of the rains.

(2) Scanty rainfall during the season, with prolonged periods of fine, clear, hot weather.

(3) Early termination of the rains.

These features are as a rule more marked in the drier districts of the interior than in the coast districts. The effect on crop production is greatest and most disastrous in the following areas:

(1) Central Burma.

(2) The Deccan, including the Bombay and Madras Deccan districts, and Hyderabad.

(3) Northwestern and Central India, more especially the South Punjab, East Rajputana, and the United Provinces.

The following important inferences are based upon the preceding presentation of facts and the experience of the past thirty years:

(1) The lower air movement of the southwest monsoon is the northward extension of the lower movement of the southeast trades. The latter is a permanent feature of the Indo-oceanic region, and the former a periodic invasion of the Southern Asian seas and peninsulas initiated over equatorial regions and propagated northward to the southern mountain barrier of the Central Asian plateau.

(2) The primary factors determining this impulse across the equator (the first stage of the establishment of the southwest monsoon) are to be sought in the permanent field of the southeast trades, and are not due to actions in the heated areas of Southern or Central Asia.

(3) The pressure conditions in the heated areas of Southern Asia and Northeast Africa determine the direction, volume, and intensity of the advance over the Indian seas to what may be termed three competing areas for rainfall (viz., Abyssinia, India, and Burma). These conditions are hence important factors in the third stage of the advance of the southwest monsoon current.

(4) The movement when fully established by these actions over the Southern Asian seas and peninsulas is continued—first, by the momentum of the lower circulation; secondly, by the release of energy accompanying aqueous vapor condensation; and thirdly, by thermal actions in Southern Asia, due to direct solar activity. The termination of the lower horizontal current by vertical movement occurs irregularly over the areas of frequent heavy rain in Southern Asia and Abyssinia, and not over a heated area in Central Asia.

(5) The total volume of aqueous vapor brought up by this circulation not only varies in amount from month to month during the season, but also from year to year. The largest variations (seasonal and annual) depend chiefly, if not entirely, upon actions in the source of supply—viz., the Indian Ocean. If those actions determine an increased or diminished supply across the equator into the Indian seas, there is a corresponding variation in the total precipitation of the three competing areas. Among such causes and actions may be prolonged and untimely diversion of the southeast trades into East Africa, as in 1896, or general weakness of the air movement over the Indian Ocean, probably accompanying a displacement and decreased intensity of the southern anticyclonic, as in 1899.

(6) The relative distribution of the total rainfall in the three areas of discharge of the aqueous vapor of the monsoon currents probably depends upon the relative intensities of the pressure conditions established during the hot weather, which are continued for a part or the whole of the monsoon by actions depending on the rainfall resulting from the initial pressure conditions—an example of the persistence of meteorological conditions and actions which is a prominent feature of Indian meteorology. The total rainfall of each of the three areas may differ considerably from the normal, but there may be partial or complete compensation on the whole. Thus it is the general (but not the invariable) rule that the rainfall variations in Burma and Assam are usually inverse to those of Northwestern India and also of India as a whole.

(7) The distribution of the rainfall in any one of the three competing areas (but more especially in India, as the largest) may vary widely from the normal—considerable deficiency in some areas accompanying considerable excess in others. This in India is undoubtedly due to local conditions—e. g., local excess or deficiency of pressure at the commencement of the period and established during the previous hot weather. These pressure variations usually accompany abnormally prolonged and heavy snowfall or very scanty snowfall in the Western Himalayas.

(8) Local or general drouth in India during the southwest monsoon may hence be due to—

(a) General weakness of the southeast trades circulation.

(b) Diversion of an unusually large proportion of the southeast trades to Southeast or East Africa during the monsoon period.

(c) Larger diversion than usual of the monsoon currents to Burma or Abyssinia.

(d) Very unequal distribution in India itself, due to local conditions established during the antecedent hot weather.

These factors are given in the probable order of their importance.

(9) Scanty rainfall or drouth during the dry season or northeast monsoon in Northern India results from absence or unusual feebleness of the cold weather storms which are the sources of rainfall at that time.

(10) The most prolonged and severe drouths in Northwestern and Central India are due to the partial or complete failure of the rainfall of at least two seasons in succession.

(11) As the two circulations in the Indian oceanic region have a common goal in the dry season (more especially from December to March), it is probable that variations in the strength of one circulation (more especially the larger) will modify the field and strength of the other circulation. It appears that this relation would be shown most strongly between the southern circulation and the upper movement of the northern circulation. And, as cold-weather storms are disturbances in that upper movement, it is possible—if not probable—that the larger variations in the number and intensity of the cold-weather storms and the amount of the cold-weather precipitation may be related to conditions in the southeast trades regions.

(12) There appears to be little or no relation between the position and intensity of the Central Asian anticyclone and the number of cold-weather storms and rainfall of Northern India in any season.

The meteorology of the period 1892-1902 is of especial interest for its confirmation of the above inferences, more especially the phenomena of the variations of rainfall in India and the causes or actions to which they are due. The year 1891 was noteworthy for a severe local famine in Rajputana and the adjacent districts to the north and east consequent on prolonged and excessive snowfall in the Western Himalayas during the winter of 1890-91. The following gives a brief summary of the more prominent features of the meteorology of this unique period:

(1) The eleven-year period 1892-1902 corresponds in length to the sun-spot period, and it may be divided into two periods of unequal length—a short period of excessive rain and a long period of deficient precipitation. The maximum of the first period was in 1893. The second period had three strongly marked minima in 1896, 1899, and 1901, that in 1899 being the absolute minimum. The following table gives, for convenience of reference, data of the mean annual and seasonal variations of rainfall of the Indian land area for each year of the period:

Variation of Mean Actual Rainfall of Period from Normal.

	Cold Weather; January and February.	Hot Weather; March to May.	Southwest Monsoon, Complete Period; June to December.	Whole year.
1891	+ 0.34	+ 0.37	— 4.25	— 3.54
1892	— 0.39	— 0.21	+ 5.69	+ 5.09
1893	+ 1.63	+ 2.72	+ 4.72	+ 9.07
1894	+ 0.48	— 0.76	+ 6.75	+ 6.47
1895	— 0.01	— 0.23	— 1.95	— 2.19
1896	— 0.42	— 0.82	— 3.59	— 4.83
1897	— 0.01	— 0.12	— 0.02	— 0.15
1898	+ 0.50	— 1.00	+ 0.93	+ 0.43
1899	— 0.38	+ 0.58	— 11.34	— 11.14
1900	— 0.02	— 0.25	— 0.26	— 0.57
1901	+ 1.47	— 0.48	— 5.12	— 4.13
1902	— 0.57	+ 0.16	— 1.64	— 2.05
Normal roughly.	1 inch	5 inches	35 inches	41 inches

(2) The following gives the chief features of the rainfall of the first period, 1892-4:

(a) The excess was almost as marked in the dry as in the wet season. This is strongly shown in the year 1893 of maximum excess.

(b) The excess was on the whole more strongly exhibited in the field of the Bombay than of the Bengal current.

(c) The rainfall of the dry season was as markedly in excess in Persia, Baluchistan, Afghanistan, and the Himalayan area as in Northern India.

(d) The maximum height of the Nile floods (in September) was above the average. They were abnormally high in 1892 and 1894.

(e) The rains were favorable over Australia and South Africa during this period, according to the reports received in India.

(f) Hence, as a general inference, the rainfall was in general excess in each year of the period over the Indo-oceanic region, and not only in the southwest but also in the northeast monsoon in Southern Asia.

(3) The chief features of the rainfall of the second period, 1895-1902, in the Indo-oceanic region were as follows:

(a) The rainfall was as deficient relatively to the normal in the cold weather as in the rains or wet season.

(b) The cold-weather or winter precipitation was almost continuously in marked defect in Asiatic Turkey, Persia, Afghanistan, Baluchistan, the Himalayan area, and South Tibet. The opposite variation obtained in Central Asia, as is shown by available data for Tashkend, Samarcand, Irkutsk, and other stations.

(c) The storms of the cold weather were fewer in number and feebler in character in each year of the period than on the average of the preceding sixteen years 1876-91.

(d) The southwest monsoon rainfall was most largely in defect in the interior districts served by the Bombay current.

(e) There was a marked tendency in each year for late commencement and early withdrawal of the monsoon currents, and for deficient rainfall throughout the whole season over the greater part of India. These features were very pronounced in the years 1896, 1899, and 1901.

(f) The most remarkable feature of the period was that the region to the south of the equator, including South and East Africa, Mauritius, and Australia, was similarly affected.

In India the years 1896 and 1899 were years of severe drouth, followed by famine over very large areas. The area in which the crops failed more or less completely was about 250,000 square miles in extent in 1896 and 500,000 square miles in 1899. In the 1899-1900 famine upward of 6,500,000 people were on famine relief for several months. The loss of cattle due to failure of water and fodder was very great, numbering many millions. In some districts from 90 to 95 per cent of the cattle died off from slow starvation and want of water. In New South Wales and Queensland almost continuous drouth prevailed from 1896 to 1902. It is estimated that more than fifty millions of sheep, value £12,500,000, were lost in New South Wales during these seven years of drouth.

Mr. Hutchins, Conservator of Forests, Cape Town, states that drouth prevailed more or less persistently over the Karoo region in South Africa from 1896 to 1903, and that cattle and sheep perished by millions. He also states that the drouth extended to British Central Africa from 1898 to 1903.

The previous statements evidence the continuity, extension, and intensity of the drouth.

The Nile floods followed very closely the variations of the rainfall in Western India. The floods of the years 1899 and 1901 were both among the lowest on record. This shows that the rainfall in the Abyssinian region was more or less generally in defect during the period and most largely in the years 1899 and 1901, when the rainfall of the Bombay current was very deficient.

Hence, as a general inference, the period 1895-1902 was characterized by more or less persistent deficiency of rainfall over practically the whole Indo-oceanic area (including Abyssinia). The economic results in the dry interior districts of India, South Africa, and Australia were the same—large loss of cattle and great loss of capital. The drouth in Southern Asia was as marked in the northeast as in the southwest monsoon, and hence the variation was not seasonal but general.

The variations of temperature, humidity, and cloud in India during the whole period were large and in direct accordance with the rainfall. In other words, during the period 1892-94 the air was damper with lower temperature than usual, and cloud above the normal. On the other hand, from 1895 to 1902 temperature was steadily in excess, cloud less than usual, and humidity below the normal.

The most remarkable variation was that of the solar radiation as indicated by observations of the solar radiation thermometer (black bulb *in vacuo*).

The most interesting feature of the meteorology of the period 1892-1902 is that the variations of the solar insolation are the inverse of those which might have been expected from the cloud and humidity data. In other words, solar radiation was in excess in the period of increased humidity and cloud, and in defect during the greater part of the period of drouth, decreased humidity, and cloud. The series of eight curves exhibited, out of a larger number prepared from the data of a number of stations in India at which these observations are carefully recorded, show the most important facts, and indicate that there was a continuous decrease of insolation on the average of all stations from 1891 to 1902. The curves for Aden, Calcutta, and Leh, it will be seen, agree in their most important features. The observations are quite concordant and probably represent a most important feature of the period. They indicate either a continuous and considerable decrease of emission of solar energy during the period, or unusually large absorption in the upper atmosphere. In order to decide this question comparison is necessary with similar data for other large areas as, for example, Europe and North America. It is, however, clear that in India the insolation data of this unique period are of exceptional interest and value.

(To be continued.)

OUR SOLAR SYSTEM.*

By Agnes M. Clerke.

Our sun is clearly middle-aged. It bears none of the marks associated with juvenility in stars; and its decrepitude is in the distant future. It is crossing, prob-

* Read before Subsection of Cosmical Physics of the British Association for the Advancement of Science.

* Knowledge.

ality, a level tract where recuperation so nearly balances expenditure that radiation can be maintained for an indefinite time at a high and fairly uniform standard. Stars of the solar type pursue the even tenor of their way with particularly few interruptions. They show little tendency to intrinsic variability. Their periodicity, when it exists, is due to the presence of a companion. Light-changes can thus be impressed upon them by external influence; they do not conspicuously arise through native instability.

Our planet, accordingly, is attached to a safe and steady luminary; one subject, not to destructive spasms, but to vicissitudes so mild as to evade distinct meteorological recognition. It is, moreover, governed by a polity settled on a broad basis of tranquillity and permanence. All this is as it should be. The conditions specified were a pre-requisite to the unfolding of human destinies. Nor can it be confidently asserted that they have been realized anywhere else. Our system may be unique; while, on the other hand, replicas of it might, imperceptibly to us, be profusely scattered through the wide realms of space. It is certain that a telescopic observer on Sirius or α Centauri would see our sun unattended; not even Jupiter could be brought into view by optical appliances in any degree comparable to those at our disposal. There are, nevertheless, strict limitations to the possible diffusion of planetary worlds like those that wander amid the zodiacal constellations. We have become aware of incapacitating circumstances, by which a multitude of stars are precluded from maintaining retinues of subordinate globes. Spectroscopic discoveries have compelled a revision of ideas as to cosmical arrangements. Especially the large proportion established by them of binary to single stars makes it impossible any longer to regard the solar system as a pattern copied at large throughout the sidereal domain. We cannot, then, compare it with any other; the mechanism of which the earth forms part must, perforce, be studied in itself, and by itself; and it may, for aught that appears, be the outcome of special and peculiar design.

This machine is self-sustaining and self-regulating; no extraneous influence noticeably affects it. This exemption from disturbance is the fortunate consequence of its isolation. A great void surrounds it. The span of Neptune's orbit is but a hand-breadth compared with the tremendous unoccupied gulf outside—unoccupied, that is to say, by bodies of substantial mass. The feebleness of star-light relatively to sun-light affords some kind of measure of the impotence of stellar attractions to compete with the overruling gravitational power that sways the planetary circulation. This it is which gives to it such remarkable stability. The incomparable superiority of the sun over his dependent orbs not only safeguards them against foreign interference, but reduces to insignificance their mutual perturbations. Hence, the strong concentration of force exemplified in our system—the absolutely despotic nature of the authority exercised—makes for a settled order by excluding subversive change.

The organization of the solar kingdom, as disclosed by modern research, is greatly more varied and complex than Laplace took it to be. His genetic scheme was, indeed, no sooner promulgated than deviations from the regularity and unanimity of movement upon which it was based began to assert their inconvenient reality. They have since multiplied; and, emerging to notice under the most unlikely aspects, they occasion incongruities which tax, for their explanation, all the resources and audacities of the most inventive cosmogonists. Let us briefly consider their nature.

The swarm of asteroids that bridge the gap between Mars and Jupiter revolve, it is true, with the general swirl of planetary movement; but use a large license as regards the shape and lie of their orbits, and their partial exemption from the rules of the road becomes entire for comets and meteors, which have proved themselves, nevertheless, to be aboriginal in our system by their full participation in its proper motion. Finally, several of the major planets set convention at defiance in the arrangement of their several households, and thereby intimate departures from the supposed normal course of development so frequent and so considerable as to shape belief even in its qualified prevalence. Thus, the anomalously short period of Phobos, the inner satellite of Mars, besides throwing doubt over its own mode of origin, tends to obscure the history of its more sedately circulating associate. The sub-systems of Uranus and Neptune exhibit, moreover, eddies of retrograde movement, suggesting primitive disturbances of a fundamental kind; while the surprising disclosures connected with Saturn's first-born, and furthest satellite, have added one more knotted thread to the tangled skein we would fain unravel. Until acquaintance was made with Phœbe, counterflows of revolution within the same satellite family were unknown, and, if contemplated at all, would have been scouted as impossible. One ternary star, to be sure— ξ Scorpii—had been recognized as probably owning an immediate and a more remote attendant, in oppositely directed orbital movement; but the cases are in many ways disparate, and the analogy, though instructive, is imperfect.

If the ninth Saturnian moon is to be regarded as sprung from the mass of its primary, a total change in the condition of the parent body must have supervened during the long interval between its separation and that of its successor Iapetus. The change, in Prof. W. H. Pickering's opinion,* was nothing less than a reversal in the sense of axial rotation. The nebulous spheroid destined to develop into the wonderful Saturnian system had a diameter, when Phœbe was thrown off from it, of sixteen million miles, and gyrated tranquilly from east to west in a period of about a year and a half. The action of sun-raised tides, however, availed first to destroy, and finally to invert this movement; for the natural outcome of tidal friction is synchronism, and this implies agreement, both in period and direction, between the rotation and revolution of the body acted upon. Acceleration through contraction did the rest; and before Iapetus entered on its separate career, the originating globe spun normally in seventy-nine days. The view that such was the course of events is plausible at first sight; yet the doubt remains whether the cause alleged was adequate to the effect produced. At the distance of Saturn, solar tidal friction exerts only about one-twenty-thousandth its power on the earth;* its efficacy would, it is true, be greatly enhanced by the distension of the mass subjected to it; but approximately to what extent, it baffles our powers of calculation to determine.

* Harvard Annals, Vol. LIII., p. 61, where, however, the reversal is explained by a shifting of the axis of rotation. The mode of action described in the text was long ago suggested by Kirkwood.

The one certain inference derivable from the diversity of facts ascertained within the last hundred years is that our world is not (so to speak) machine-made. The *modus operandi* employed to disengage the planets from their nebulous matrix was not of cast-iron rigidity; it was adaptable to circumstances; it left room for the display of boundless inventiveness in details. This, nevertheless, was made to consist with the perfect preservation of the main order, both in design and operation. The general plan is broadly laid down and unmistakable, and the springs of the machine are undisturbed in their free play. And for the primary reason that departures from regularity, which might, in any way, prove a menace to stability, affect bodies of negligible mass. The great swing of settled movement goes on irrespectively of them. *De minimis non curat lex.* Thus, the erratic behavior of comets is harmless only because of their insignificance. If pursued by substantially attractive masses, it could not fail to jeopardize the planetary adjustments. Even the asteroids would be unsafe neighbors but for their impotence; and it is remarkable that Mercury, by far the smallest of the major planets, circulates along a track of the asteroidal type. It would seem as if an important size carried with it an obligation to revolve in an orbit of small eccentricity, inclined at a low angle to the principal plane of the system. The reason why this should be so is not obvious; but were it otherwise, the equilibrium, now so firmly established, would subsist precariously, or not at all.

The assertion, indeed, that it is firmly established, can only be made under reserve. We are ignorant of any causes tending toward its overthrow; yet they may supervene, or be already subtly active. One such lurking possibility is the presence of a resisting medium in interplanetary space. Waifs and strays of matter must, at any rate, be encountered there—outlawed molecules, self-expelled from the gaseous envelopes of feeble globes; thin remnants of cometary paraphernalia, driven off amid the fugitive splendors of perihelion; products of ionic dissociation set flying by the impact of ultra-violet light—and all disseminated through an ethereal ocean, which "is cut away before, and closes from behind," as moving bodies traverse it. That its indifference is shared by ordinary material substances, when in the last stage of attenuation, is a plausible but unverified conjecture. It is only safe to say that retardation of velocity in what may pass for empty space is insensible, or null.

There may, nevertheless, be springs of decadence in the solar system. Some of them have been discussed by M. Poincaré,† whose confidence in the reassuring demonstrations of Laplace and Lagrange is inversely proportional to the magnitude of the terms they were forced to neglect. They dealt with fictitious globes, devoid of appreciable dimensions, and swayed by the strict Newtonian law. But the real planets and their satellites are acted on by other forces as well, frictional, magnetic, radio-repulsive; and their joint effects may not be wholly evanescent. The tidal drag on rotation undoubtedly occasions a small but irretrievable loss of energy. The moon, for instance, as M. Poincaré states, now gains, by the reactive consequences of tidal friction in widening its orbit, no more than 1-28 the *vis viva* of which the earth is deprived by the infinitesimal slowing down of its rotation. And the remaining 27-28 being dissipated abroad as heat, is finally abstracted from the system. The ultimate state, we are told, toward which the planetary mechanism tends, is that of the synchronous revolution, in a period of about twelve years, of all its members. This might, apart from a possibly resisting medium, have indefinite permanence; otherwise precipitation to the center would gradually ensue, and one solitary sphere, cold, stark, and unilluminated, would replace the radiant orb of our cerulean skies with its diversified and exquisitely poised *cortège*. Unsecured drafts upon futurity, however, are not among the most valuable assets of science; and a consummation so incalculably remote may be anticipated by a score of unforeseen contingencies. What can be, and has been, ascertained is the relative durability of the scheme with which the visible destinies of the human race are so closely connected. It will, beyond question, last long enough for their accomplishment. Curiosity that would seek to penetrate further is likely to remain ungratified.

But this is not all. There are other and incalculable items in the account. The sun, although an autocrat within his own dominion, is himself subject to external influences. As a star, he is compelled to follow whithersoever the combined attractions of his fellow-stars draw him; nor can we thoroughly interpret the summons which he obeys. The immediate outcome in the transport of the solar system toward the constellation Lyra has, it is true, been determined; but the eventual scope and purpose of the journey remain profoundly obscure. The pace is to be reckoned as leisurely; twelve miles a second is little more than half the average stellar speed. We should, however, probably suffer no inconvenience from being whirled through the ether in the train of such a stellar thunderbolt as Arcturus. Only the excessive velocities of any adventitious bodies we might happen to pick up would betray to ordinary experience the fact of our own swift progress. As it is, our sweepings from space appear to be scanty. If shreds from inchoate worlds, or dust of crumbled worlds, strewed the path of our system, they should be annexed by it in its passage, temporarily or completely; and we should then expect to find the apex of the sun's way marked, if no otherwise, by the predominant inflow from that quarter of comets and meteors. Yet there is no trace of such a preference in the distribution of their orbits. Hence the enforced conclusion that the sun has attached to him, besides the members of his immediate household, an indefinite crowd of distant retainers, which, by their attendance upon his march, claim with him original corporate unity. To this rule there may be a few exceptions. An occasional aërolite probably enters the earth's atmosphere with hyperbolic velocity, and takes rank accordingly as, in the strictest sense, a foreign intruder; but the broad truth can scarcely be challenged that the sun travels through a virtual void.

* G. H. Darwin, Phil. Trans. Vol. CLXXII., p. 526; Moulton, Astroph. Jour., Vol. XI., p. 110.

† Annuaire du Bureau des Longitudes, 1898.

We can, however, see no necessity why he should for ever continue to do so. Widely different conditions seem to prevail near the center and out toward the circumference of the sidereal world. What may be designated the interior vacuity of the Milky Way is occupied mainly by stars of the solar type, including one to our apprehension super-eminent over the rest; they are separated by vast, apparently clear intervals; they are non-nebulous, and of stable constitution. This secure habitat is ours for the present; it may, nevertheless, at some future time be exchanged for one less exempt from disturbance. The shape and size of the sun's orbit are utterly unknown; the changes of environment, accordingly, that will accompany the description of it defy conjecture. Our actual course is inclined at a small angle to the plane of the Milky Way. It will presumably become deflected; but perhaps not sufficiently to keep our system clear of entanglement with the galactic star-throngs. In our ignorance of their composition, no forecast of the results can be attempted; they are uncertain and exorbitantly remote. Moreover, the comparative slowness of the sun's motion in a manner guarantees the permanence of his subsisting cosmical relations. For anything that science can tell, they may ultimately be subverted by some preordained catastrophe; but the possibility lies outside the field of legitimate speculation.

The universe, as reflected in the mind of man, gains extent as the mirror acquires polish. Early astronomers conceived of but one solar system, and one "dædal earth," upon which the "pale populace of heaven" rained influences sinister or propitious. Later, human egotism took another form. The whole universe was assimilated to our particular little settlement in it. Terrestrial conditions were universalized. None divergent from them were counted admissible or profitable. But one answer seemed possible to the perpetual *cui bono?* with which restless thought assailed the heavens. But one purpose was regarded as worthy of fulfillment; that of multiplying, in distant sidereal climes, copies of our own planet, and of providing suitable locations for myriads of intellectual beings, as little alien to ourselves as might be compatible with the minimum of diversity in their material surroundings.

The spread of this astral philanthropy has, nevertheless, been in some measure checked by the advance of knowledge. Our position and circumstances have been shown by it to be, if not quite peculiar, at any rate very far from inevitable. It has reduced by a process of exclusions to a relatively limited number the class of stars that can fairly be regarded as possible centers of vitality; it has immensely widened the scope of discernible variety in cosmical arrangements, and held out warnings against errors of interpretation due to congenital prepossessions. And we shall surely not wander from the truth by recognizing our inability to penetrate all the depths and intricacies of Infinite Design.

Diving bells are employed so little at the present time that it is interesting to note in Engineering an account of their use in the Folkestone harbor works recently completed. In preparing the foundations for some of this work, dredging buckets were employed in removing sand, gravel and mud to a depth of 12 to 15 feet below the sea-bed. At this depth a bed of hard sand was encountered which the buckets could not remove efficiently, and resort was had to a pair of diving bells, each 13 x 10½ x 6 feet in size and weighing 26 tons out of water. Four men working four hours, and then resting eight hours, constituted a shift, and enough shifts were engaged to carry on the work continuously. The bells were lighted by electricity and supplied with air by steam-driven compressors.

LHASA AND CENTRAL TIBET.*

By G. Ts. Tsybikoff.†

After a journey of twenty-two days over the sparsely-populated north Tibetan plateau, our caravan of pilgrims camped July 19[‡], 1900, on the banks of the Sanchu, at the northern foot of the Bumza Mountain. The caravan had been formed at the Kumbum monastery in Amdo, and started April 24 on the way to Lhasa. There were about seventy persons in the party, almost all of them Amdo and Mongolian Lamas, and were quartered in seventeen traveling tents. About 200 mules transported men and baggage.

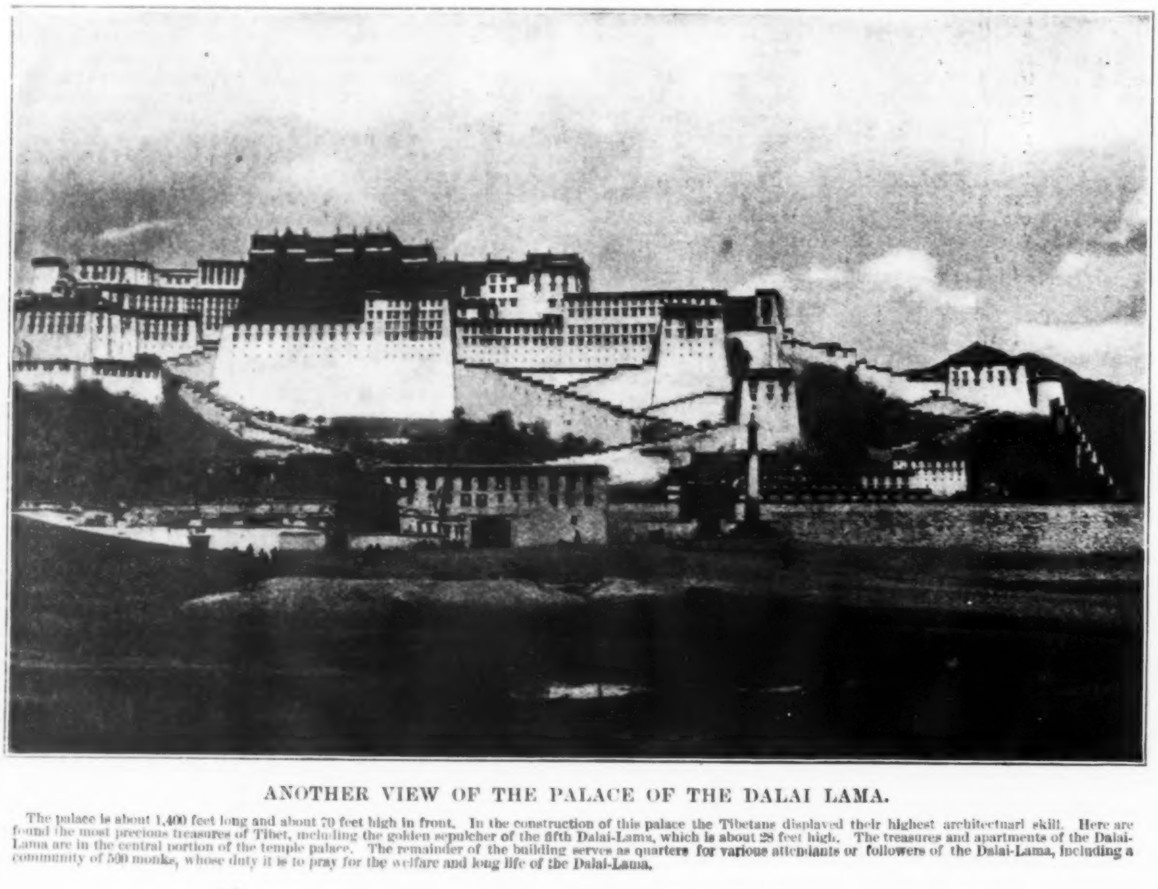
THE PALACE OF THE DALAI LAMA AT LHASA.

The palace of the Dalai-Lama, Potala, is about two-thirds of a mile west of the city, and built upon a rocky height. The foundation of the palace, tradition says, was laid by Srongzang Khan during the seventh century. The main central portion, called the "red palace," was added some time later. The palace and additions were planned to serve as a means of defense.

We here first met inhabitants of Central Tibet. Close to the road was a great black tent in which lived the local soldiery, an advance post on the lookout for foreigners. They had special orders to watch during the present year for P. K. Kosloff's Russian expedition, of which the authorities at Lhasa had received information as early as April.

The guards immediately approached our camp, but seeing that it was an ordinary caravan of pilgrims, the men were soon busied in making trifling exchanges to supply their wants, our men keeping a watchful eye on articles that might readily be stolen. After four short marches from here we reached the Nakchu monastery, the residence of two governors of the local nomads, appointed by the central government of Tibet. One of them belongs to the clergy and is called "Khambo," the other is a civilian, called "Nansal." They supervise the collection of taxes and decide important matters that arise between the natives; and also control the government stations between Nakchu and Lhasa. It also devolves upon them to stop Europeans bound for Lhasa and immediately to notify the central government about them, as well as about all suspicious persons. I was halted as belonging to the last category, due to the chief of our caravan, who, out of friendship to the Tibetans and possibly to shift responsibility for himself, reported that there were Buriats in the party. Although the Buriats had of late been freely admitted, yet we were each obliged to pay 5 taels (about $4), which at once excluded us from the suspicious class and opened our way to Lhasa.

The Nakchu monastery serves also as a custom house. Here all pilgrims are obliged to pay a tax on each tent, the revenue being used for keeping the local pastures in grass. No penalty is imposed upon those who refuse to pay the toll, although an indirect punishment is inflicted by prohibiting the local residents from having anything to do with delinquents.



ANOTHER VIEW OF THE PALACE OF THE DALAI LAMA.

The palace is about 1,400 feet long and about 70 feet high in front. In the construction of this palace the Tibetans displayed their highest architectuarl skill. Here are found the most precious treasures of Tibet, including the golden sepulcher of the fifth Dalai-Lama, which is about 28 feet high. The treasures and apartments of the Dalai-Lama are in the central portion of the temple palace. The remainder of the building serves as quarters for various attendants or followers of the Dalai-Lama, including a community of 500 monks, whose duty it is to pray for the welfare and long life of the Dalai-Lama.

* Translated from the Izvestia of the Imperial Russian Geographical Society, St. Petersburg, vol. xxxix, 1903, part iii, pp. 187-218, for the Smithsonian Institution.

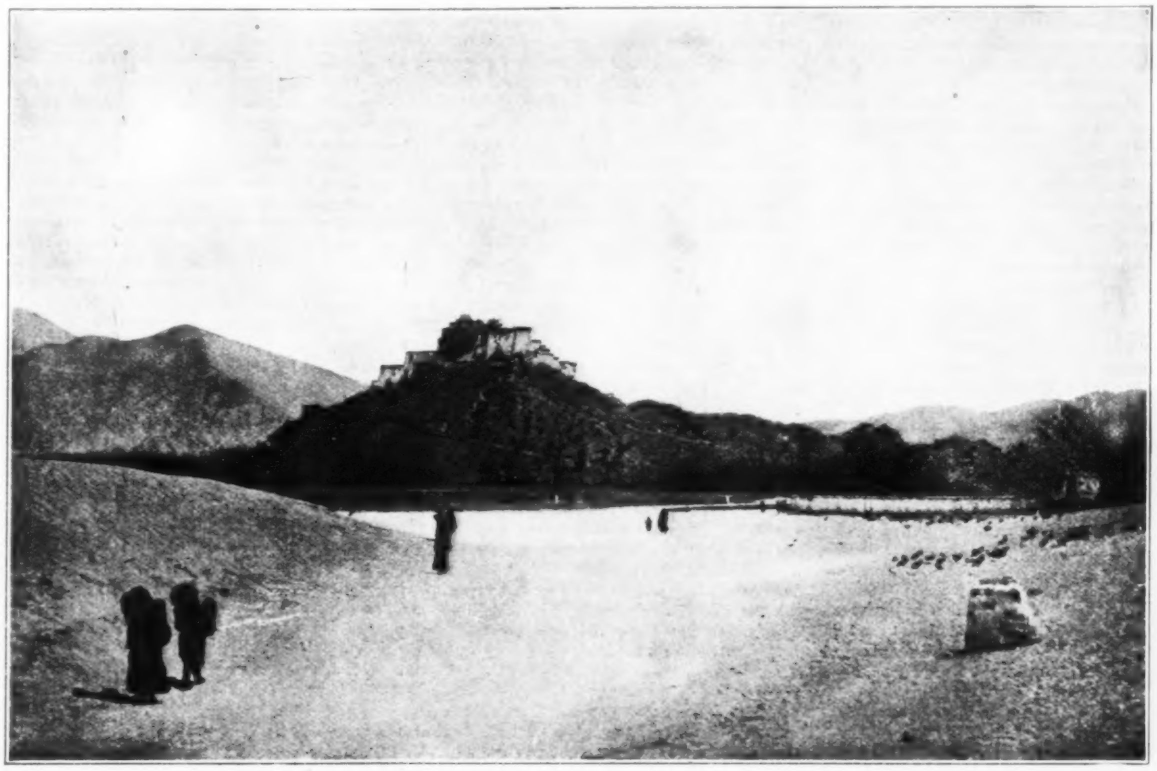
† "M. Tsybikoff is a Buriat by birth, and a Lamaist by religion, who finished his education at a Russian university, and after having prepared himself for this journey, went quite openly, like so many other Buriat pilgrims, to Lhasa. There he remained more than twelve months, making an excursion to Tsetang (or Chetang) and visiting some of the most venerated monasteries, after having previously stayed, during his journey to Lhasa, in the Mongol monasteries of Labrang and Kumbum. During his stay at Lhasa he made, moreover, a most valuable collection of books, written by all the most renowned Lama writers during the last nine centuries. This collection represents 319 volumes on philology, medicine, astronomy and astrology, history, geography, and collections of ku-rims (praises, prayers, and incantations, and so on). It has been presented by the Russian Geographical Society to the Academy of Sciences."—The Geographical Journal, London, January, 1904.

‡ The dates in this paper are old style, or twelve days behind the Gregorian calendar.

After losing half a day here, the caravan left the monastery, situated on the left bank of the small river Dre-chu,* and 7 miles away approached the left bank of the Nakchu. In the rainy season, when the river runs deep and swift, it is impossible to cross without boats, which evidently the native nomads can not build. Thence the caravan reached the broad Sunshan Valley, bounded on the north by Mount Samtan Kansar. From this valley, across the low crest of Chog-la, the road enters the Dam Valley, inhabited by descendants of Mongols brought into Tibet by the Khoshot Gushi Khan, in the middle of the seventeenth century. They are at present practically assimilated with the Tibetans, although some still use Mongol felt tents, and have not forgotten how to milk the mares and to make kumys. Mongol words have disappeared from their language, except official titles and some special technical terms. The Dam Mongols are subject to the Manchu Amban, who resides at Lhasa. Their occupation is cattle raising.

From Dam across Lani-la, or "double range," we enter a pass where we come to the first agricultural settlement of Central Tibet. It is more civilized here. The Pondo-chu is crossed by pedestrians over a bridge. In the rainy season baggage is taken across in skin boats, while animals ford the stream. On the right side of this swift river stands the castle Pondo-dzong.

* Chu = river in Tibetan.



A VIEW OF THE PALACE OF THE DALAI LAMA FROM THE WEST.

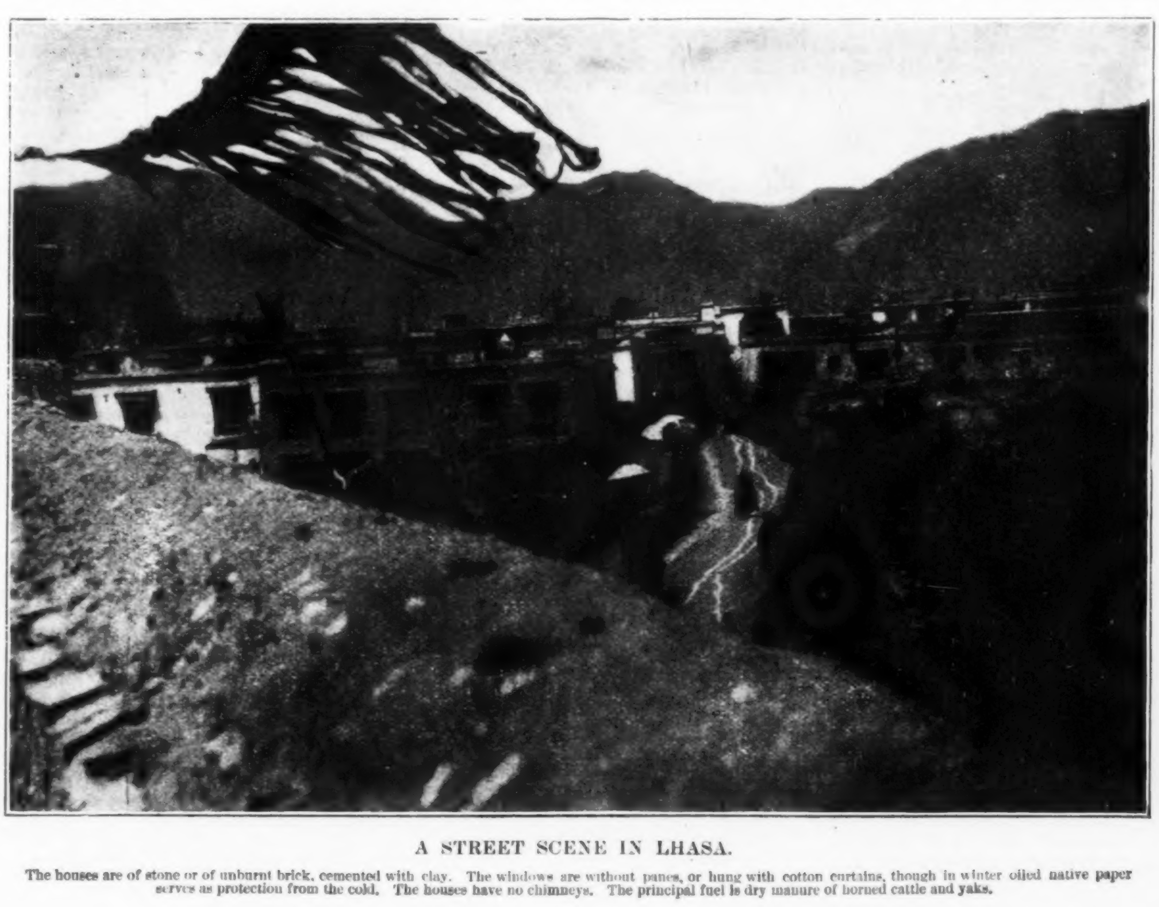
The unequal distribution of wealth and the subservience of poverty to wealth are conspicuous throughout Tibet. There is such little commerce that labor is very cheap, the most expert weaver of native cloth receiving about 8 cents and board per day, while an unskilled woman or man laborer earns only 2 or 3 cents. The highest salary is paid to the Lamas, the prayer readers, who receive 10 cents a day for incessant reading. A house servant almost never receives pay beyond food and meager clothes.

Twenty-seven miles farther on the journey we reached Penbu, or Penyul, one of the most thickly populated regions of Tibet. Caravans have from here a choice of two roads—one, without crossing the ridge, along the right bank of the U-chu, and the other straight across the high ridge of Go-la. About ten miles from the top of the ridge lies the capital of Tibet, Lhasa, which we entered August 3, 1900, after three months' journey from Kumbum.

Central Tibet—that is, the two provinces of U (Wei) and Tsang—has not been visited by Europeans since 1845, at least the principal part of it, although the literature on Tibet in general has increased every year. No Russian traveler entered the country either before or certainly after the prohibition. But for the last thirty years Tibet has been annually visited by Buriats and Kalmuks, who are Russian subjects. Many of these pilgrims made notes on Tibet, but thus far only the report of Zayaeff (eighteenth century) and the diary of the Kalmuk Baza-bakshi have been published.

It must be borne in mind that having penetrated a forbidden country in the guise of an ordinary pilgrim, obliged to pose before the natives as one in search of salvation in the holy land, and constantly in danger of suspicion as other than a pilgrim, the amount of information gathered under such circumstances could not have been great. I was well aware that several years ago an Indian penetrated Central Tibet and established connections with a certain ecclesiastic in Tashilhunpo, that through this lama's servant he received books at Calcutta, and that both lama and servant were executed at Lhasa for daring to allow the admission of a foreigner.

Tibet is truly a land of mountains, and the natives aptly call it "Snowland." In the region we traversed while in Tibet there are two snow mountains, Samtan-Kansar on the eastern end of the Nyan-chu-tangla and the crest of Kar-la on the southwestern side of the cir-



A STREET SCENE IN LHASA.

The houses are of stone or of unburnt brick, cemented with clay. The windows are without panes, or hung with cotton curtains, though in winter oiled native paper serves as protection from the cold. The houses have no chimneys. The principal fuel is dry manure of horned cattle and yaks.

cular lake, Yamdok. The mountains that did not reach the snow line were nearly all treeless and their tops bare.

The upper lands of the river valleys are narrow and unfit for cultivation, but the middle and lower portions are wider and enable the industrious Tibetans to grow cereal crops. The steep and rocky mountains are the source of many swift streams during the rainy season, but most of them dry out when the rains cease. Many streams and springs, however, collect water at each rainfall in numerous irrigating ditches that keep the water mills busy.

The year may be divided into two seasons, rainy and dry. In 1900 the dry season commenced in Lhasa on September 13, when the last rain of the year fell. October and November were entirely dry. The first snow fell December 7, but melted the next day. It snowed once in January, in February three times, in March four times. The first thunder was heard on March 14, and twice in April. The snow melted in the valleys immediately after falling, but remained for a time on the mountains. The first considerable rain fell on May 5, then on May 7, June 8, July 17, August 13, and twice early in September. These rains were generally late in the evening or at night, in squalls and large drops, and in May and June were frequently accompanied with hail. The clouds generally moved from west to east.

Temperature observations were recorded at dawn, 1 P. M., and 9 P. M. for two hundred and thirty-five days. The average morning temperature was 41.45 deg. F.; 1 P. M., 58.33 deg. F.; 9 P. M., 48.65 deg. F. December was the coldest month, with an average morning temperature of 18.3 deg. F.; noon, 34.5 deg. F., and evening, 26.8 deg. F.; and June was the warmest month, with average morning temperature 58.6 deg. F.; noon, 73 deg. F., and evening 63.3 deg. F. The large rivers are entirely free of ice in winter, but the small ones are covered by a thin crust. The soil freezes only at the surface.

The total population of Tibet has been estimated from the fantastic 33,000,000 down to 3,500,000, or even 2,500,000. The most reliable evidence indicates that Central Tibet has not more than about 1,000,000 inhabitants. Reliable statistics of the whole population were not obtainable, but it is certainly not very great, for the many narrow river valleys between high, rocky mountains are unfit for agriculture and could not sustain many inhabitants. Besides, the numerous unmarried ascetic ecclesiastics of both sexes, and epidemics of smallpox and other fatal diseases against which the Tibetans are almost defenseless, not only retard an increase, but would appear to gradually decrease the country's growth. More than 10 per cent. of the population of Lhasa and neighboring monasteries died of smallpox in 1900. Further evidence of the limited Tibetan population appears from the fact that only about 20,000 monks from all the monasteries in the vicinity gather at the so-called "great Monlam of Lhasa." This, remember, in the center of Lamaism, where the principal sanctuaries and the higher Tszanite schools are located, which to a considerable extent are supported by the government. The native Tibetans call themselves Bo(d)-pa, and it is also customary to refer to people according to the names of particular regions. Thus the inhabitants of Tsang are called "Tsang-pa," etc. The floating population of the cities is composed of Chinamen, Nepalese, Kashmiris, and Mongols.

Most of the Chinamen, especially the emigrants from Ssu-ch'uan, are employed in the garrison camps of the large cities, while those engaged in commerce transact their small trade with the local inhabitants, principally the women. . . .

The Nepalese and Kashmiris, about equal in numbers, are merchants almost exclusively, though a few of the former are artisans. According to tradition the Nepalese were for a long time the architects of the temples, the sculptors of the Buddha statues, and the ikon painters of Tibet, and they are still the most expert cloth dyers, and are skillful as gold and silver smiths, from small trinkets to the gilt roofs of temples. The Buddhist Nepalese, in distinction from the ruling caste, Gurka, in their kingdom, are called Bä(l)-bo. They avoid marriage with Tibetans, for such ties mean death in their native land, and they therefore remain permanently in Tibet. The Kashmiris, on the contrary, always marry Tibetans, whom they first convert to Mohammedanism, and rear their children in that religion.

In administrative matters the Chinamen are responsible directly to the Amban, who resides and officiates at the southwest end of the city, near the ruins of the old city wall. The Nepalese and Kashmiris are subject to their elders, who serve as deputies in affairs before the central government of Tibet, with its jurisdiction. The Mongols, about 1,000 of them, are all monks, and only temporary residents, about 15 per cent of their number changing annually. They are distributed over the various monasteries according to their parishes. The Russian subjects among them in 1900 numbered 47, being Buriat Lamas from the region across the Baikal, with one Kalmuk from the Astrakhan government. They are subject to the monastery regulations.

The social classes are the nobility, the clergy, and the peasantry. The nobility consists of the descendants of former rulers of separate principalities and descendants of the fathers of Dalai Lamas and Panchens, who are invested by the Manchu court with the rank of prince of the fifth degree.

The princes, together with the monasteries and their parishes, are large land owners, and the peasants are serfs to them. The central government, or the Dalai Lama, owns, of course, more land and serfs than the classes named.

There is apparently no distinct military caste. Military service accompanies the privilege of special land grants, but we could not secure detailed information about it.

The houses are of stone or unburnt brick, cemented with clay. Most of those in the villages are one story high, while in the cities they are of two or three stories. The windows are without panes, or hung with cotton curtains, though in winter oiled native paper serves as protection from the cold. Fireplaces are used only for cooking. The houses have no chimneys, the smoke escaping as best it may through doors and windows, except that houses with upper stories have roof openings that somewhat alleviate the smoke nuisance, though equally a discomfort during rain. The principal fuel is dry manure of horned cattle and yaks. The clothing is of special design, made from native cloth in various colors. The poor classes wear white, the cheapest color; the richer people red and dark red, the soldiers dark blue, and yellow is used by higher dignitaries and princes. Women prefer the dark red cloth. Of course, other colors are also met with. In proportion to their means, the Tibetans dress rather elegantly. Their jewelry is of gold, silver, corals, diamonds, rubies, pearls, turquoise, and other stones.

Tsamba, or roasted barley flour, mixed with either tea or barley wine, is one of the principal foods. The commonest vegetable is the radish. The favorite dish among all classes is "tsamtuk," a soup made by boiling zamba in water and flavored with bits of radish. Tsamtuk is best when made into broth with crushed bones, but it is comparatively expensive, and only the well-to-do can afford it every day.

The Tibetans are fond of raw meat, and when entertaining they serve meat either raw or not fully cooked. The principal meats are yak, mutton, and pig. Beef is not considered good, and ass and horse meat are not used at all. The poor classes also eat fish. We did not see the Tibetans use fowl as food, although they keep chickens for the eggs. Butter is much used, serving principally to whiten or flavor tea, and melted butter is burned in lamps before the idols. Sour milk, prepared also as thib-sho, is regarded as very noble food, and in poetry indicates something pure white.

Both sexes of all classes are very fond of barley wine, and owing to its cheapness and slight intoxicating properties it constitutes the principal beverage of the poor. The men are heavy smokers of leaf tobacco in pipes, and the monks, while avoiding the pipe, consume no less tobacco in snuff. Because of the high cost of tobacco, and to reduce its strength, the laymen mix it with the leaves of the plant "shol," and the monks use the ashes of ram and goat dung for that purpose.

The principal characteristics of the Central Tibetan may be described as stupidity and flattery, doubtless explained by the economic and political conditions of the country. They are also pious through fear of losing the protection of the gods or of angering them. On this account they have frequent sacrifices, bowing and circling before their sanctuaries. They are very impressionable and superstitious, and at each new episode in their lives they seek explanation from Lama seers and prophets, and when sick they prefer to take barley grains blessed by Lamas and prophets, or to have curing prayers read to them, rather than resort to medicine, which, by the way, is less developed in Central Tibet than in Amdo or Mongolia. Despite all, the Tibetans seem to be inclined to joviality, which manifests itself in song and dance during their frequent sprees and public holidays.

In their family life polyandry and polygamy exist, and the marriage of several brothers to one woman or of several sisters to one man are regarded as ideal relations. . . . Women enjoy perfect freedom and independence and take an active part in business affairs, often managing extensive enterprises entirely unaided.

Agriculture is the chief occupation of the settled population. Barley is the standard crop, from which tsamba is prepared; then comes wheat, for wheat flour; beans for oil, and peas, used by the poorer class in form of flour, or crushed for horses, mules, and asses. The field work is done principally by "dzo" (a cross breed of yak and ordinary cattle), yaks, and asses. The principal beasts of burden are the small, hardy asses, and to some extent the ordinary horned cattle. Inhabitants of the highland regions are engaged in cattle raising, breeding yaks, sheep, and some horses. They use yaks for burden, and sheep in some places. The horse and mule are, to a certain extent, a luxury to the Tibetan, and are therefore kept only by the well-to-do. The native horses and mules are very small and homely, so that the rich people use only those imported from western China. In the stables of the Dalai Lama and Panchen there are blooded horses from India.

Commerce consists in supplying the cities and monasteries with agricultural products in exchange for articles of insignificant local manufacture and foreign import. The excess of domestic products is exported. The Tibetan has very few wants, chiefly limited to necessities, although some inclination toward objects of luxury, expensive ornaments, objects of cult and home adornment may be observed. The standard money is a silver coin valued at about 10 cents.

The unequal distribution of wealth and the subservience of poverty to wealth are conspicuous. There is such little commerce that labor is very cheap, the most expert weaver of native cloth receiving about 8 cents and board per day, while an unskilled woman or man laborer earns only 2 or 3 cents. The highest salary is paid to the Lamas, the prayer readers, who receive 10 cents a day for incessant reading. A house servant almost never receives pay beyond food and meager clothes. . . .

(To be continued.)

ESTIMATING DISTANCES.*

By Commander William H. Beehler, U. S. Navy.

The naval officer in command of a battleship in a squadron has no problem of greater importance in the evolutions of naval tactics or at target practice than the determination of the distances of other vessels in the fleet for the distance of the target.

The inventive genius of the navy has devoted itself to inventions for determining distances, ranges, etc., and some of these instruments are admirable, but none are at all times perfectly reliable. Fiske's stadimeter is an excellent instrument, his range finder has also in practice under favorable conditions proven to be very good, but for target practice the gun itself is generally conceded to be the best range finder. But in practice and especially in a naval engagement these instruments and means will not always be available and therefore every contribution to the subject of range finding or estimating distances should be diligently considered and practised for successfully executing maneuvers and conducting target practice.

When executive officer of the U. S. S. "Montgomery" under the command of Capt. George A. Converse (at present rear-admiral and chief of bureau of ordnance) the writer was directed to carry out exercises for estimating distances. The captain sent the navigator out in the steam launch with a stadimeter to go to varying distances of from 2,000 to 4,000 yards. Upon arrival at predetermined distances the captain required the executive and divisional officers to estimate the distance of the steam launch. Gun pointers and sharpshooters were likewise all required to secretly report their several estimates of the distances of the steam launch. When this was first tried the estimates by different officers and men varied as much as 500 yards, but after a little practice the variations differed by less than 50 yards and a large percentage of the estimates were very close. This exercise was another evidence of the fact that practice makes perfect, and the great improvement in our target practice demonstrates this most forcibly. The terrible disaster recently experienced on board the "Missouri" is greatly to be deplored, but notwithstanding the appalling risks, the necessity for such target practice is too urgent to permit us to entertain the thought of restricting target practice.

The advantages of this practice of the "Montgomery" at Pensacola before the war bore good fruit subsequently in the destruction of Fort Canuelo at the bombardment of Porto Rico, May 12, 1898, where the "Montgomery" threw 314 5-inch shell from six 5-inch guns in a period of exactly five minutes, at the end of which time there was nothing left of that fort.

While in command of the U. S. S. "Monterey" in the Asiatic fleet last year (1903) the writer adopted a simple method of estimating distances by which officers and men became very expert in estimating distances vere accurately.

This method consists of getting two lines of sight, one with the right and the other with the left eye. The observer simply sights with his right eye along the right forearm extended to its full extent and pointing with the right forefinger at the distant object. He then closes the right eye and sights with the left eye, holding the right arm and head rigid as before. In this case the second or left-eye line sight will point to the right of the object first sighted with the right eye, a distance equal to one-tenth of the distance that the said object is from the pointing finger of the observer's right hand. These two lines of sight intersect at the point of the forefinger of the right hand, and with lines joining the two eyes and lines joining the object with the point to which the left-eye line of sight shall have moved to the right, form two right-angled triangles which are opposite and similar.

The eyes are normally 2.75 inches apart and the right forearm fully extended will bring the point of the right forefinger 27.5 inches from the right eye; the proportion of 10 to 1 exists between the base and altitude of the smaller right-angled triangle, and the same proportion exists between the larger triangle in which the base is the estimated distance that the left-eye line of sight shall have moved to the right of the object and the altitude is the distance of the object from the intersection of these two right-angled triangles.

An example of the practical use of this method will be clearly understood. While at Chefoo the "Monterey" was required to take position 300 yards from the "Monadnock." The "Monadnock" was 55.5 feet beam and when directly astern of the "Monadnock" observer pointed at the mast of the "Monadnock" and observed that the left-eye line of sight moved to the right a distance equal to a beam and a half of the "Monadnock," a distance equal to 55.5 feet plus 27.75 or 83.25 feet, making the distance of the "Monadnock" 832.5 feet. By pointing to the port edge of the after turret of the "Monadnock," a point just 34.5 feet from the edge of the starboard rail at its greatest midship section, the distance was found to be 900 feet when the left-eye line of sight pointed to the right at a

* From Proceedings of U. S. Naval Institute.

distance such that the "Monadnock" might just fill the space between that point and the position of her starboard rail, a distance of 90 feet. It was required that the "Monterey" should be 300 yards or 900 feet from the "Monadnock" and every officer and man on board could at any time determine the distance.

The distance which the left-eye line of sight moves to the right of the previously observed line of sight with the right eye, is only an estimate and if that estimate is erroneous the distance will have been estimated thereby with an error ten times that of the first estimated lateral displacement. If this lateral error amounts to 10 yards the estimated distance will be 100 yards in error, but such error will not be realized by those who are expert in this method. A little practice, especially in observing distances of objects of known dimensions, will make the error in the estimated lateral displacement of the left-eye line of sight very small, much less than a foot, and therefore invariably give the distance within 5 or 6 feet of the true distance, even when the object, such as a steamer at sea, may be 2 or 3 miles distant.

A necessary corollary of this is that the length of a ship or any other object at a known, or previously determined distance, will also be given by observing the estimated lateral displacement of the left-eye line of sight and giving the estimated length of that object (for example, if a ship when broadside on) as one-tenth of her distance from observer.

This method of observing and estimating distances was used on board the "Monterey" while under the writer's command on the Asiatic station every day at setting up drill at morning and evening quarters. Divisional officers then required the men to estimate the distances of vessels in the harbor taking advantage of knowledge of the length and beam of the ships or of boats near by as might offer.

This method is not altogether limited to determine distances during daylight but with range lights at say 300 feet apart when broadside on, the distance of the range lights from the observer might be very accurately determined at, say 1,500 yards, when the lateral displacement of the left-eye line of sight should happen to be exactly one-half the distance between the lights.

While estimating distances on board the "Monterey" by the method used by Capt. Converse it was found that the estimates of distances differed widely under different conditions of the atmosphere, whether hazy or in bright sunlight, but this method of the right and left-eye lines of sight will be found by practice to be quite independent of atmospheric conditions. The method is manifestly always available; a stadimeter may be left below, or out of adjustment, or otherwise not available, but every officer and man will always appear with his eyes and arms and intelligent use will by practice make him more or less independent of instruments. The gun is claimed to be the best range finder, but in an engagement it may and probably will be often impossible to determine where the shell from your gun struck, if other ships and guns are firing at the same time, and the writer knows of no instrument that can be depended upon to meet all the requirements that will arise in a naval engagement. This method is therefore earnestly commended as a most valuable aid for successfully carrying out maneuvers in naval tactics and in target practice.

Since officers and men are not all uniform in size it is evident that the distance of the end of the right forefinger with the right arm fully extended in front of the right eye, from the right eye, is not always exactly 27.5 inches, neither is the distance between the two eyes always exactly 2.75 inches; but the ratio between those two distances of ten to one always is or can be made to be the same. This ratio will have to be determined for each and every individual, and in case practical experiment should show this ratio to be wrong, the individual can readily make this ratio, either by prolonging the point of intersection of the two triangles by means of a lead pencil in case the ratio of the length of forearm and distance between the eyes is less than ten to one, or by using the thumb as pointer in case the ratio is greater than ten to one. The proportion of ten to one is the most convenient factor to use and each individual should be taught to ascertain his own personal range-finding ratio for estimating distances by two lines of sight from the right and left eyes.

In many scientific discussions on range finding it is the fashion to regard all mere estimates of distances as utterly unreliable, but estimates and good judgment are required even when using the accurate instruments of precision, and observers are required to depend upon their estimates of coinciding reflected images, etc. In the most scientific range finder which the writer has ever used, viz., Carl Zeiss's stereoscopic range finder, in which the stereoscopic plastic or depth of perspective is the principle, the observer is called on to estimate when the image of the distant object appears to be at the same perspective depth as certain figures on a scale blending into the perspective view of that distant object. Here good judgment is a requisite and observer must have two eyes of equally good visual power. It is therefore absurd to ridicule methods of estimating distances.

Careless observations of distances by this simple method of the two lines of sight with right and left eyes will never give reliable results. This method, though simple, requires rigid compliance with its conditions. The right forearm must be fully extended and directly in front of the right eye. When the right eye is closed and the left eye line of sight used the observer must be very careful to keep his arm and his head exactly in the same position, the very slightest deviation will cause a great error and vitiate the predetermined ratio of the distance between the eyes and the distance of the end of the index finger from the right eye. Again the observer must be extremely careful that the two triangles formed by the intersection of the right-eye and left-eye lines of sight are strictly right-angled triangles, and also that the point of the lateral displacement of the left-eye line of sight to the right of the object is a point in a line parallel with the line between the eyes or at right angles to the right-eye line of sight.

Again, in estimating distances by using known values—of the length of a ship, for instance—the observer must be sure that the observed ship is broadside on, or if not broadside on he must make allowance for the way she is heading. It is evident that if the observer is off the starboard quarter of a distant vessel 300 feet long for example, and if his first right-eye line of sight pointed at her stern and his second or left-eye line of sight pointed to her bow, the lateral left-eye line of sight would not have been displaced a distance of 300 feet, but only about 225 feet, and the distance in that case would be about 2,250 feet instead of 3,000 feet.

The greatest and in fact the only objection to this method of estimating distances is its simplicity. It is so very simple that few will take the trouble to rigidly adhere to its requirements, but to those who do strictly comply, practice will prove it to be much better than some instruments of precision that claim to be accurate range finders. This method may be said to be never liable to get out of adjustment, but that is not true, for every careless observation, when observer does not have his arm properly extended directly in front of the right eye or should move his arm or his head between the observations of both eyes, may be designated as being out of adjustment.

It is earnestly hoped that the naval service will take up this method and require every officer and man to practise it at every opportunity. It is always available, requires no apparatus and costs nothing but strict practice. But correct estimates will only be obtained by strictly adhering to the requirements. It is so easy that it is difficult to comply with its strict requirements.

The writer had the tops of the turrets marked with white lines as a dumb compass that facilitated taking bearings of distant objects from the bridges, that proved to be a very decided aid in estimating distances.

To insure accuracy in estimating distances it is advisable for divisional officers to have a right-angled triangle constructed of light battens of dimensions such as to simulate the observer's small right-angled triangle—

The base may have a small groove to fit over the nose. Then closing left eye observe along the edge with right eye, sighting on distant objects. Then close the right eye and sight along the hypotenuse with left eye and estimate how far the left-eye line of sight points to the right of the object first sighted.

FLOATING DOCKS.

AT a meeting of the Institution of Civil Engineers a paper on "Floating Docks" was read by Lyonel E. Clark, M. Inst. C.E. The following is an abstract of this communication:

The paper deals with the floating dock as a method of getting at the under-water portion of ships, and the author points out that this appliance, although in common use, is less known in England than elsewhere, which he ascribes to the fact that the rise and fall of tides on the British coasts naturally favors the excavated form of dock, whereas in non-tidal waters, as he shows by statistics, the floating dock is equally as common as the other.

The simplest form of floating dock consists of a hollow pontoon, forming the buoyant or lifting portion, with two hollow side walls on top of the same, forming the controlling portion of the system; to this the name of "box" dock has been applied. When built of iron, however, such docks required means of protection against rust and decay, and the self-docking principle was evolved. The first form of this consisted in constructing the box dock in such short sections that they could lift each other, and to this type the name of "sectional" dock has been given. Later, in order to avoid the use of the numerous small sections, a modification was introduced by which two sections of any length lifted a third section between them, by allowing it to rest on the projecting ends of their pontoons. Such "sectional" docks, however, presented no longitudinal rigidity whatever, and consequently another departure was made in which the pontoons only were built in sections, being bound together by continuous side walls, and the self-docking operation consisted in removing any one pontoon from under the side walls, and lifting it onto the rest of the dock. This type is known as the "sectional pontoon" dock. The longitudinal rigidity of this type, however, was not very great, and having the problem set them of lifting both long and short vessels of equal displacement on the same dock, the author's firm introduced, in 1895, a new type which is now known as the "Havana" type. In this, the continuous side walls are on each side instead of on top of the pontoons, thus extending downward to the full depth of the same, and forming strong girders, to the sides of which the pontoons are bolted. The self-docking of this type is carried out by unbolting the desired pontoon from between the side walls, and docking it on the rest of the dock. Later still, when yet greater rigidity was required, the firm introduced a new form, known as the "bolted sectional" dock, this being an ordinary sectional dock, but with the different sections rigidly bolted together. The self-docking of this type is effected by so designing the end sections with points or projections that these points can take under the square-ended central section and lift it, or alternatively, enter between the walls of the same when an end section is being lifted.

The author then proceeds to describe the one-sided types of dock. One is the "depositing" dock, in which the necessary stability is obtained by attaching the L-shaped dock to a floating outrigger by means of parreled hinged booms, the body or pontoon of the dock being built in the form of separate fingers. These fingers, which carry the ship, are floated in between similar fingers of pile work or masonry placed on the shore. The dock is allowed to sink, leaving the ship supported on this fixed staging, and the dock is then free to deal with other vessels. The other type, namely, the "off-shore" dock, has the pontoon as a continuous structure, and stability is obtained by connecting the dock, by means of parallel booms, to columns fixed in the foreshore, the top boom being connected to a weighted cam which allows the dock to heel slightly athwartships, so that its horizontality can be maintained by regulating the valves. Lastly, a combination of the foregoing two types is mentioned, wherein the continuous pontoon is used in conjunction with a floating outrigger, on which are carried the dock's boilers and any small repairing shops and machinery required in connection with the dock.

The paper then passes on to the chief problems that confront the designer of a floating dock. The most important of these is the determination of the longitudinal strength required when carrying a short, heavy ship on a long dock; and closely analogous to this is also the determination of the strains to which a dock is subjected in a seaway. The transverse strains due to the ship resting centrally on the dock are also treated of, and different types of internal bracing are discussed, especially the design of that portion of the dock which comes directly under the ship's keel. Lastly, the local strains on the dock's structure due to water pressure when submerged, and the working stresses allowable under such conditions, are referred to.

The stability of a floating dock next engages the author's attention, and the ordinary method and rules employed are given, for the stability of a ship is governed by different conditions from that of a dock. In the former, the shape of the water planes varies but slightly, but the angle of heel may be very great; whereas in the latter the shape of the water planes is always varying, but the angle of heel permissible is so small that it can be virtually disregarded in its effects. The stability of a dock is, therefore, best expressed by means of a curve giving the metacentric heights at all states of immersion, from the time when it is sunk ready to receive a ship until the vessel is lifted, and the pontoon deck is above water. The method of calculating the stability of the one-sided types is also treated of, showing how, in the case of the depositing dock, it is the floating outrigger which has to provide the righting moments, while in that of the off-shore dock, the weights on the regulating cams have to be arranged to give the required control.

The paper next proceeds to discuss the advantages and disadvantages of the floating dock as compared with the excavated dock. First, it is pointed out that the time required for constructing a floating dock is much less than that needed for the excavated dock, and instances are given of large docks having been completely designed and built in well under a year. The advantage of the mobility of the floating dock is then discussed, both from the point of view that this allows of its being built in the cheapest and most suitable yard and then towed to its destination, and also that in the case of alterations to its site, or development of the port where it is placed, it is not tied to such site or port, but may be bodily moved to any more suitable place. The advantage of mobility from a strategical point of view is also shown, and it is pointed out how such a dock would be useful in connection with any existing arsenals, which are naturally always placed at some distance from the sea, for it could be sent down the channel to pick up and patch "lame ducks" before they attempted the narrow passage leading to the arsenal. The author mentions that it has, indeed, been proposed that a floating dock should accompany a fleet into action, ready to pick up wounded vessels after an engagement, but in his opinion this is not yet a practical scheme, the difficulties of propelling such a dock even at ordinary cruising speeds being insurmountable. At the same time, he strongly advocates the use by all naval powers of a floating dock, towed by a vessel containing ordinary ship-repairing tools, which could at any time be easily transferred to any base that the fleet may have seized, or could provide or supplement the docking accommodation in those home ports where the same did not exist or was of insufficient capacity. The drawback to the extensive use of such a dock would naturally be the depth of water required at its moorings, but it is pointed out that the maximum amount of excavation required for the berth of a floating dock would never be more than that required for the excavated dock, with the advantage that whereas in the latter case the excavation would have

to be made entirely in the dry, in the former it would merely be the removal of material by ordinary dredgers. On the other hand, the floating dock possesses many advantages in the choice of site, since it can be placed end-on with the stream, thus facilitating the entrance of vessels; and it does not require its entrance to be placed, like that of most graving-docks, more or less at right angles to the stream. Again, in rivers which are subject to a strong freshet, the floating dock is equally available either at high or low water, whereas a stone graving dock would either have to be built very much deeper than required, or else would be submerged in times of flood. In connection with this, the author discusses the point whether a vessel on a floating dock is not much better placed for purposes of repairing or painting than in the bottom of an excavated dock, and points out how open to light and air are vessels on the former. He also claims that this openness of the floating dock has other advantages in that it allows them to deal with vessels of much greater length than the dock itself, and instances of this facility are adduced; while the one-sided docks have an equal advantage as regards beam of vessels lifted. It is admitted that floating docks have their limitations, represented by the amount of their lifting power, but at the same time it is argued that though they may not be able to lift a vessel entirely, they can frequently lift it enough to enable the required repairs to be effected.

The first cost of floating docks is dealt with, and in order that an idea of their cost may be obtained, a list of the actual hull weights of several docks of different types is given.

The cost of working is also dealt with, and it is pointed out that the floating dock has a great advantage in respect of the cost of coal and oil, as the power required to lift a ship is much less than that required for a graving dock of similar capacity. Instances are given where it costs, on the average, less than 18s. to lift vessels displacing 3,000 tons.

The cost of maintenance of a floating dock is gone into in some detail, and in the appendix many instances of the actual amounts expended on repair and unkeep are given, based on the results of a number of years; from these it is found that the average cost is a little more than 1 per cent per annum of the first cost of the dock.

Some further statistics are given as to the useful life of a floating dock, and iron docks which have now been at work for over forty years are mentioned, from which the author concludes that the useful life of a floating dock may be fairly taken as at least fifty years. He points out that a life of this duration requires only a sinking fund equal to 1 per cent per annum on the first cost of the dock invested at 2½ per cent.

In conclusion, a few of the most common appliances in the machinery of a floating dock are mentioned and illustrated.

THE WATERPROOFING OF FABRICS.*

By H. HIELD.

IT will be convenient to divide waterproof fabrics into two classes, viz., those which are *impervious* to water, and those which are *water-repellent*. It is important to make this distinction, for, although all waterproof material is made for the purpose of resisting water, there is a vast difference between the two classes. The physical difference between them can be briefly summed up as follows: Fabrics which are completely impervious to water comprise oil-skins, mackintoshes, and all materials having a water-resisting film on one or both sides, or in the interior of the fabric. Those coming under the second heading of water-repellent materials do not possess this film, but have their fibers so treated as to offer less attraction to the water than the water molecules have for themselves.

The principal members of the first group are the rubber-proofed goods; in these the agent employed is rubber in greater or less quantity, together with other bodies of varying properties. Before enlarging on this class, it will be necessary to give a short description of the chemical and physical properties of rubber.

Rubber, or caoutchouc, is a natural gum exuding from a large number of plants, those of the *Euphorbiaceæ* being the chief source for the commercial variety. The raw material appears on the market in the shape of blocks, cakes, or bottle-shaped masses, according to the manner in which it has been collected. It possesses a dark brown—sometimes nearly black—exterior; the interior of the mass is of a lighter shade, and varies from a dingy brown to a dirty white, the color depending on the different brands and sources. In the raw state its properties are very different from what they are after going through the various manufacturing processes, and it has only a few of the characteristics which are generally associated with India rubber. Chemically it is a complex hydrocarbon with the formula $C_{10}H_{16}$, and appears to consist of a highly porous network of cells having several different resins in their interstices. It is perfectly soluble in no single solvent, but will yield some of its constituents to many different solvents. At a temperature of 10 deg. C., raw caoutchouc is a solid body and possesses very little elasticity. At 36 deg. C. it is soft and elastic to a high degree, and is capable of being stretched sixteen times its length. Further increase of temperature lessens its elastic properties, and at 120 deg. C. it melts. While in the raw condition it has several peculiar properties, one of which is: After stretching, and cooling suddenly while stretched, it retains its new form, and only regains its former shape on being warmed. Another striking feature is its strong adhesive capacity; this property is so powerful that the rubber cannot be cut with a knife unless the blade is wet; and freshly-cut portions, if pressed together, will adhere and form a homogeneous mass. From these facts it will be seen how it differs from rubber in the shape of a cycle tire or other manufactured form.

The most valuable property possessed by raw caoutchouc is that of entering into chemical combination with sulphur, after which its elasticity is much increased; it will then bear far greater gradations of

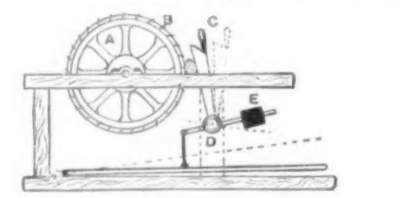


FIG. 1.

heat and cold. This chemical treatment of caoutchouc with sulphur is known as "vulcanizing," and, if properly carried out, will yield either soft vulcanized rubber or the hard variety known as vulcanite. On the other hand, caoutchouc, after vulcanizing, has lost its plastic nature, and can no longer be molded into various shapes, so that in the production of stamped or molded objects, the customary method is to form them in unvulcanized rubber and then to vulcanize them.

Raw caoutchouc contains a number of natural impurities, such as sand, twigs, soil, etc.; these require removing before the manufacturing processes can be carried out. The first operation, after rough washing, is to shred the raw material into small strips, so as to enable the impurities to be washed out. This process is carried out by pressing the rubber against the surface of a revolving drum (*A*, Fig. 1), carrying a number of diagonally arranged knives, *B*, on its surface. A lever, *C*, presses the rubber against the knives; *D* is the fulcrum on which *C* works, *E* being a weight which throws back the lever on the pressure being removed. During this operation a jet of water is kept

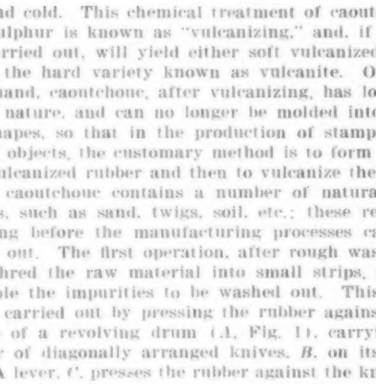


FIG. 2.

playing on to the knives to cool and enable them to cut.

Following this comes the passage between a pair of corrugated steel rollers (as shown in Fig. 2). These rollers have each a different speed, so that the rubber gets stretched and squeezed at the same time. Immediately over the rollers a water pipe is fixed, so that a steady stream of water washes out all the sand and other extraneous matter. In Fig. 2, *AA* are the steel rollers, while *B* is a screw working springs which regulate the pressure between the rollers. The power is transmitted from below from the pulley, *C*, and thence to the gearing.

The next operation, after well drying, is to thoroughly masticate the shredded rubber between hot steel rollers, which resemble those already described, but usually have a screw-thread cut on their surfaces. Fig. 3 shows the front view of this masticating machine, *A* being the rollers, while the steam pipe for heating is shown at *B*. Fig. 3A gives a top view of the same machine, showing the two rollers.

After passing several times through these, the rubber will be in the form of homogeneous strips, and is

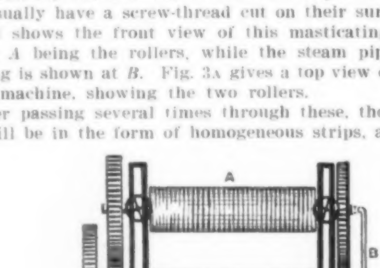


FIG. 3.

then ready either for molding or dissolving. As this paper is dealing solely with waterproofed textiles, the next process which concerns us is the dissolving of the rubber in a suitable solvent. Benzol, carbon-bisulphide, oil of turpentine, ether, and absolute alcohol, will each dissolve a certain amount of rubber, but no one of them used alone gives a thorough solution. The agent commonly employed is carbon-bisulphide, together with 10 per cent of absolute alcohol. Whatever solvent is used, after being steeped in it for some hours the caoutchouc swells out enormously, and then requires the addition of some other solvent to effect a complete solution. A general method is to place the finely shredded rubber in a closed vessel, to cover it with carbon-bisulphide, and allow to stand for some hours. Toward the end of the time the vessel is warmed by means of a steam coil or jacket, and ten parts absolute alcohol are added for every 100 parts of carbon-bisulphide. The whole is then kept gently stirred for a few hours. Fig. 4 shows a common type of the vessel used for dissolving rubber. In this diagram, *A* is the interior of the vessel, and *B* a revolving mixer in the same. The whole vessel is surrounded by a steam jacket, *C*, with a steam inlet at *D* and a tap for condensed water at *E*. *F* is the cock by which the solution is drawn off.

After the rubber is dissolved, about 12 to 24 per cent of sulphur is added, and thoroughly incorporated with the solution. The sulphur may be in the form of chloride of sulphur, or as sulphur pure and simple. A very small quantity of sulphur is required to give the necessary result, 2 to 3 per cent being sufficient to effect vulcanization; but a large quantity is always added to hasten the operation.

Even after prolonged treatment with the two solvents, a solution of uniform consistency is never obtained; clots of a thicker nature will be found floating in the solution, and the next operation is to knead it up so as to obtain equal density throughout. Fig. 5 will give an idea of how this mixing is done.

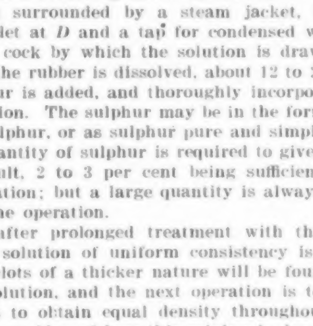


FIG. 3A.

At the top of a closed wooden chamber is a covered reservoir, *A*, containing the solution of rubber. A long slit at the base of this reservoir allows the solution to fall between sets of metal rollers, *BBB*, below. Neighboring rollers are revolving in opposite directions, and at different speeds, so that, after passing all three sets of rollers, and emerging at the bottom, the solution should be of uniform consistency. *CCC* are the guiding funnels, and *EE* are scrapers to clear the solution from the rollers. *D* is a wedge-shaped plug worked by a rack and pinion, and regulates the flow of the solution.

It now remains to apply the rubber to the fabric and vulcanize it. Up to this stage the sulphur has only been mechanically mixed with the rubber; the aid of heat is now required to bring about chemical combination between the two. This process, which is known as "burning," consists in subjecting the rubber-covered fabric to a temperature of about 120 deg. C. Sulphur itself melts at 115 deg. C., and the temperature at which combination takes place must be above this. Fig. 6 shows one of the methods of spreading the rubber on the cloth. *A* is the tank containing the solution with an outlet at the bottom arranged so as to regulate the flow of solution. The fabric passes slowly underneath this, receiving as it travels a thin coating of the waterproofing. The two rollers at *B* press the

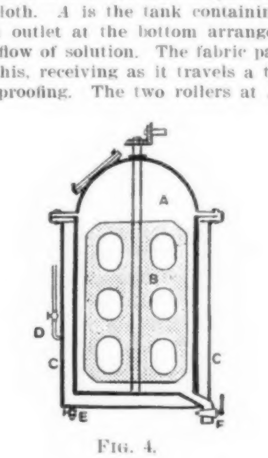


FIG. 4.

solution into the fabric and distribute the proofing evenly over the entire surface.

After leaving the two squeezing rollers, the cloth travels slowly through a covered chamber, *C*, having a series of steam pipes, *EE*, underneath, to evaporate the solvent; this condenses on the upper portion of the chamber, which is kept cooled, and flows down the sides into suitable receptacles. After this the proofed cloth is vulcanized by passing round metal cylinders heated to the necessary temperature, or by passing through a heated chamber. Fig. 7 shows the spreading of rubber between two fabrics. The two cloths are wound evenly on the rollers, *BB*; from this they are drawn conjointly through the rollers, *D*; the stream of proofing solution flowing down between the rollers, which then press the two fabrics together with the rubber inside. The lower rollers marked *CC* are heated to the necessary degree, and cause the rubber and sulphur to combine in chemical union.

So far the operation of proofing has been described as though pure rubber only was used; in practice the rubber forms only a small percentage of the proofing material, its place being taken by cheaper bodies. One of the common ingredients of proofing mixtures is boiled linseed oil, together with a small quantity of litharge; this dries very quickly, and forms a glossy, flexible film. Coal-tar, shellac, colophony, etc., are all used, together with India-rubber varnish, to make

* Technics.

different waterproof compositions. Oil of turpentine and benzol form good solvents for rubber, but it is absolutely essential that both rubber and solvent be perfectly anhydrous before mixing. Oil of turpentine, alcohol, etc., can be best deprived of water by mixing with either sulphuric acid or dehydrated copper sulphate, and allowing to stand. The acid or the copper salt will absorb the water and sink to the bottom, leaving a supernatant layer of dehydrated turpentine or whatever solvent is used. All the sulphur in a rubber-proofed cloth is not in combination with the rubber; it is frequently found that, after a lapse of time, rubber-proofed material shows an efflorescence of sulphur on the surface, due to excess of sulphur, and occasionally the fabric becomes stiff and the proofing scales off. Whenever a large proportion of sulphur is present, there is always the danger of the rubber forming slowly into the hard vulcanite state, as the substance commonly called vulcanite consists only of ordinary vulcanized rubber carried a stage further by more sulphur being used and extra heat applied. If, after vulcanizing, rubber is treated with caustic soda, all this superfluous sulphur can be extracted; if it is

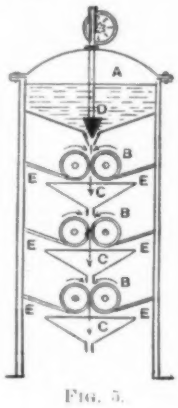


FIG. 5.

then well washed, the rubber will retain its elasticity for a long period. With the old methods of proofing, a sheet of vulcanized rubber was cemented to a fabric with rubber varnish, and frequently this desulphurizing was performed before cementing together. The result was a flexible and durable cloth, but of great weight and thickness, and expensive to produce.

The chemistry of rubber is very little understood; as mentioned previously, rubber is a highly complex body, liable to go through many changes. These changes are likely to be greater in rubber varnish, consisting of half a dozen or more ingredients, than in the case of rubber alone. The action of sunlight has a powerful effect on rubber, much to its detriment, and appears to increase its tendency to oxidize. Vulcanized rubber keeps its properties better under water than when exposed to the air, and changes more slowly if kept away from the light. It appears as though a slight decomposition always takes place even with pure rubber; but the presence of so many differently constituted substances as sometimes occur in rubber solutions no doubt makes things worse. Whenever a number of different bodies with varying properties are consolidated together by heat, as in the case of rubber compositions, it is only reasonable to expect there will be some molecular re-arrangement going on in

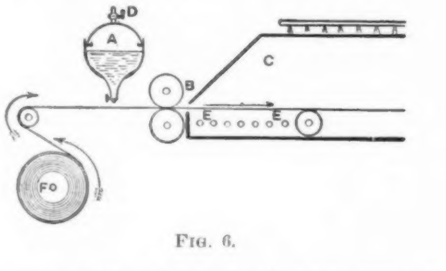


FIG. 6.

the mass; and this can be assigned as the reason why some proofings last as long again as others. Some metallic salts have a very injurious action on rubber, one of the worst being copper sulphate. Dyers are frequently warned that goods for rubber proofing must be free from this metal, as its action on rubber is very powerful, though but little understood. As is generally known, grease in any form is exceedingly destructive to rubber, and it should never be allowed in contact in the smallest proportion. Some compositions are made up by dissolving rubber in turpentine and coal-tar; but in this case some of the rubber's most valuable properties are destroyed, and it is doubtful if it can be properly vulcanized. Owing to rubber being a bad conductor of heat, it requires considerable care to vulcanize it in any thickness. A high degree of heat applied during a short period would tend to form a layer of hard vulcanite on the surface, while that immediately below would be softer and would gradually merge into raw rubber in the center.

The different brands of rubber vary so much, especially with regard to solubility, that it is always advisable to treat each brand by itself, and not to make a solution of two or more kinds. Oilskins and tarpaulins, etc., are mostly proofed by boiled linseed oil, with or without thickening bodies added. They are not of sufficient interest to enlarge upon in this article, so the second, or "water repellent" class, has now to be dealt with.

All the shower-proof fabrics come under this heading, as well as every cloth which is pervious to air

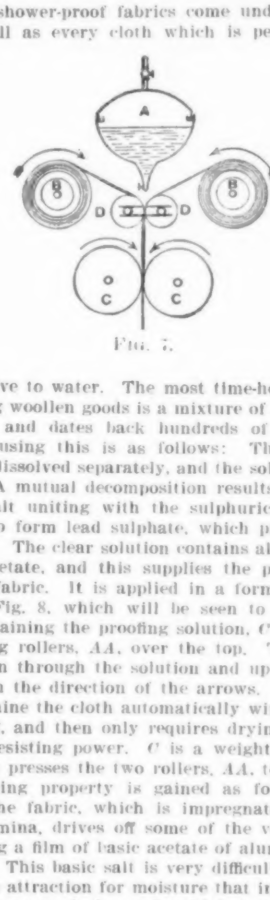


FIG. 7.

and repulsive to water. The most time-honored recipe for proofing woollen goods is a mixture of sugar of lead and alum, and dates back hundreds of years. The system of using this is as follows: The two ingredients are dissolved separately, and the solutions mixed together. A mutual decomposition results, the base of the lead salt uniting with the sulphuric acid out of the alum to form lead sulphate, which precipitates to the bottom. The clear solution contains alumina in the form of acetate, and this supplies the proofing quality to the fabric. It is applied in a form of machine shown in Fig. 8, which will be seen to consist of a trough containing the proofing solution, *C*, with a pair of squeezing rollers, *AA*, over the top. The fabric is drawn down through the solution and up through the squeezers in the direction of the arrows. At the back of the machine the cloth automatically winds itself onto a roll, *B*, and then only requires drying to develop the water-resisting power. *C* is a weight acting on a lever which presses the two rollers, *AA*, together. The water-repelling property is gained as follows:

Drying the fabric, which is impregnated with acetate of alumina, drives off some of the volatile acetic acid, leaving a film of basic acetate of alumina on *each wool fiber*. This basic salt is very difficult to wet, and has so little attraction for moisture that in a shower of rain the drops remain in a spheroidal state, and fall off. In a strong wind, or under pressure, water eventually

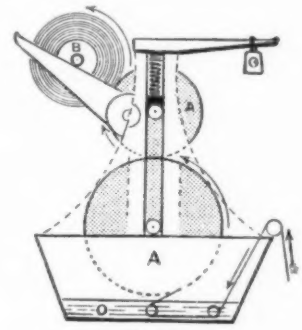


FIG. 8.

penetrates through fabrics proofed in this manner; but they will effectually resist a sharp shower. Unfortunately, shower-proofed goods, with wear, gradually lose this property of repelling water. The equation representing the change between alum and sugar of lead is given below. In the case of common alum there would, of course, be potassium acetate in solution besides the alumina.

Alum.		Sugar of lead.
$Al_2K_2(So_4)_4$	+	$4Pb(C_2H_3O_2)_2$
Lead sulphate.	Potassium acetate.	Aluminium acetate.
$= 4PbSo_4$	$+ 2KC_2H_3O_2$	$+ Al_2(C_2H_3O_2)_6$

Now that sulphate of alumina is in common use, alum need not be used, as the potash in it serves no purpose in proofing.

There are many compositions conferring water-resisting powers upon textiles, but unfortunately they either affect the general handle of the material and make it stiff, or they stain and discolor it, which is

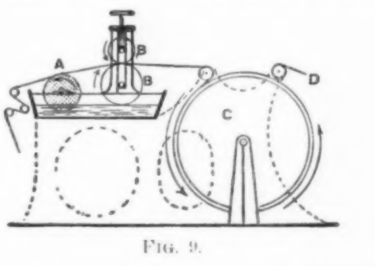


FIG. 9.

equally bad. A large range of waterproof compositions can be got by using stearates of the metals; these, in nearly every case, are insoluble bodies, and when deposited in the interior of a fabric form a water-resisting "filling" which is very effective. As a rule these stearates are deposited on the material by means of double baths; for example, by passing the fabric through (say) a bath of aluminium acetate, and then, after squeezing out the excess of liquid, passing it through a bath of soap. The aluminium salt on the fabric decomposes the soap, resulting in a deposit of insoluble stearate of alumina. This system of proofing in two baths is cleaner and more economical than adding all the ingredients together, as the stearate formed is just where it is required "on the fibers," and not at the bottom of the bath.

One of the most important patents now worked for waterproofing purposes is on the lines of the old alumina process. In this case the factor used is resin, dissolved in a very large bulk of petroleum spirit. The fabrics to be proofed (usually dress materials) are passed through a bath of this solution, and carefully dried to drive off the solvent. Following this, the goods are treated by pressing with hot polished metal rollers. This last process melts the small quantity of resin, which is deposited on the cloth, and leaves each single fiber with an exceedingly thin film of resin on it. It will be understood that only a very attenuated solution of resin is permissible, so that the fibers of the threads and not the threads themselves are coated with it. If the solution contains too much resin the fabric is stiffened, and the threads cemented together; whereas if used at the correct strength (or, rather, weakness) neither fabric nor dye suffers, and there is no evidence of stickiness of any description.

Fig. 9 shows a machine used for spreading a coat of either proofing or any other fluid on one side of the fabric. This is done by means of a roller, *A*, running in the proofing solution, the material to be coated traveling slowly over the top and just in contact with the roller, *A*, which transfers the proofing to it. Should the solution used be of a thick nature, then a smooth metal roller will transfer sufficient to the fabric. If the reverse is the case, and the liquid used is very thin, then the roller is covered with felt, which very materially adds to its carrying power. As shown in Fig. 9, after leaving the two squeezing rollers, *BB*, the fabric passes slowly round a large steam-heated cylinder, *C*, with the coated side uppermost. This dries the proofing and fastens it, and the cloth is taken off at *D*.

Besides stearates of the metals, glues and gelatines have been used for proofing purposes, but owing to their stiffening effect, they are only of use in some few isolated cases. With glue and gelatine the fixing agent is either tannic acid or some metallic salt. Tannic acid converts gelatine into an insoluble leather-like body; this can be deposited in the interstices of the fabric by passing the latter through a gelatine bath first, and then squeezing and passing through the tannic acid. Bichromate of potash also possesses the property of fixing the proteid bodies and rendering them insoluble.

HOW IMMIGRANTS ARE INSPECTED.*

By Dr. ALLAN MCLAUGHLIN, U. S. Public Health and Marine Hospital Service.

INSPECTION of our immigrants may be said to begin in Europe. The immigrant usually buys his steamship ticket in his native town from an agent or subagent of the steamship company. The agents of the best steamship lines are held responsible by the company for the passengers they book for America, and if they ship one of the excluded classes they are likely to lose their agency. This makes the agent examine the applicants for tickets, and probably quite a large number of defectives are refused passage by agents of the first-class lines. These defectives then usually try some less particular and smaller lines and take chances of escaping inspection at the Canadian or Mexican borders.

The next scrutiny to which the immigrant is subjected is that of the steamship authorities at the port of embarkation. This was formerly a perfunctory examination, and is so still, as far as some lines are concerned, but first-class lines, notably the English and German, examine the immigrants carefully and with due regard for our laws. The strict enforcement of our laws, and especially the imposition of one hundred dollars' fine for bringing to our ports any case of a contagious character, have occasioned some improvement in the inspection made by ships' doctors at European ports. At the port of embarkation the immigrants' names are recorded upon lists or manifests, each list containing about thirty names. After each name the steamship officials are required by law to record answers to a certain number of queries relating to the immigrant.

Section 12 of the act of 1903 provides that the manifests shall state, in answer to the questions at the top of the manifest sheet, the full name, age, and sex; whether married or single; the calling or occupation; whether able to read or write; the nationality; the race; the last residence; the seaport of landing in the United States; the final destination, if any, beyond the port of landing; whether having a ticket through to such final destination; whether the alien has paid his own passage, or whether it has been paid by any other person or by any corporation, society, municipality, or government, and if so, by whom; whether in possession of thirty dollars, and if less, how much; whether going to join a relative or friend and if so, what relative or friend, and his name and complete address; whether ever before in the United States, and if so, when and where; whether ever in prison or almshouse or an institution or hospital for the care and treatment of the insane or supported by charity; whether a polygamist; whether an anarchist; whether coming by reason of any offer, solicitation, promise or agreement, expressed or implied, to perform labor in the United States, and what is the alien's condition of health, mental and phys-

* Popular Science Monthly.

ical, and whether deformed or crippled, and if so, for how long and from what cause.

The master or first officer and the ship's surgeon are required by the same law to make oath before an immigration officer at the port of arrival that the list's manifests are to the best of their knowledge and belief true, and that none of the aliens belongs to any of the excluded classes. Each alien is furnished with a card, with his name, the number of the list on which his name appears and his number on that list. The cards of minor children are given to the head of the family. These cards are valuable and necessary for identification, and facilitate inspection at the port of arrival.

The condition of the steerage quarters of a modern steamship depends largely upon the age of the ship and the degree of overcrowding. The steerage of a first-class ship of recent construction will afford accommodations equal to those accorded second-cabin passengers on less progressive lines. First-class lines are careful also to prevent overcrowding. On some of the smaller and older ships the accommodations are limited, and overcrowding is permitted. But it is safe to say that the worst steerage accommodations to be found on any ship entering New York harbor to-day are infinitely better than the best afforded by the sailing vessels or old "sidewheelers" of the past.

On entering New York harbor the ocean liners are boarded by the State quarantine authorities, and the immigrants inspected for quarantinable disease, such as cholera, small-pox, typhus fever, yellow fever, or plague. Then the immigrant inspectors and a medical officer of the Public Health and Marine Hospital Service board the vessel and examine the cabin passengers, paying particular attention to the second cabin. This cabin inspection is very necessary, and, before its institution, the second-class cabin was the route most often employed by persons who found it necessary to evade the law. After the completion of the cabin inspection the ship's surgeon reports any cases of sickness among the aliens in the ship's hospital. The medical inspector examines these cases and later arranges for their transfer, if deemed advisable, from the ship to the immigrant hospital. The immigrants are then taken from the ship upon barges to the immigrant station, Ellis Island.

The medical examination at Ellis Island is conducted according to a system which is the result of many years of development. The doctors work in pairs, and divide the inspection between them. The immigrants, coming in single file, are examined for certain defects by the first doctor, who detains each one long enough to keep a space of ten to fifteen feet between the immigrants. The second doctor, placed about thirty feet from the first, disregards that part of the examination intrusted to his colleague and confines his examination to such defects as are not looked for by the first doctor. The file of immigrants makes a right-angle turn just as it reaches the second doctor and this enables the examiner to observe the side and back of the passenger in the shortest time possible.

The examiners follow a routine in this examination, and the scrutiny begins at the approaching passenger's feet, before he comes within fifteen feet of the examiner. The examiner's scrutiny beginning at the feet travels upward, and the eyes are the last to be inspected. In this way, lameness, deformity, defective eyesight (through efforts to adjust his vision, after making the turn, to a new course) are detected. The gait and general appearance suggest health or disease to the practised eye, and aliens who do not appear normal are turned aside, with those who are palpably defective, and more thoroughly examined later.

The medical examiners must ever be on the alert for deception. The nonchalent individual with an overcoat on his arm is probably concealing an artificial arm; the child strapped to its mother's back, and who appears old enough to walk alone, may be unable to walk because of infantile paralysis; a case of favus may be so skillfully prepared for inspection that close scrutiny is required to detect the evidences of recent cleansing, and a bad case of trachoma may show no external evidence and be detected only upon everting the eyelid.

After the last alien in line has passed the doctor, the suspected ones turned aside are thoroughly examined; idiots and those suffering with a loathsome or dangerous contagious disease are certified and sent to the board of special inquiry. Cases not deemed fit to travel are sent to the hospital, and cases with some disability likely to make them a public charge are certified accordingly and also sent to the board of special inquiry. Minor defects, such as anemia, loss of an eye, loss of a finger, poor physique, low stature, etc., are recorded on the alien's card and he is allowed to go to the registry clerk and immigrant inspector in charge of the manifest, who takes the defect into consideration as contributory evidence, and may or may not send him to the board.

After passing the doctors, the immigrants are grouped, according to the number of their manifest sheet, into lines of thirty or less. At the head of each line is a registry clerk, or interpreter, and an immigration inspector. The clerk, or interpreter, interrogates each alien, and finds his name, and verifies the answers on the manifest sheet before him, and if, in the opinion of the immigration inspector, the immigrant is not clearly and beyond doubt entitled to land, he is held for the consideration of the board of special inquiry. A board of special inquiry, according to the law of 1903, "consists of three members selected from such of the immigrant officials in the service as the commissioner general of immigration, with the approval of the secretary of commerce and labor, shall designate as qualified to serve on such boards." "The decision of any two members of a board shall prevail and be final, but either the alien or any dissenting member of said board may appeal through the commissioner of immigration at the port of arrival, and the commissioner general of immigration to the secretary of commerce and labor, whose decision shall then be final, and the taking of such appeal shall operate to stay any action in regard to the final disposal of the alien, whose case is so appealed, until receipt by the commissioner of immigration at the port of arrival, of such decision." To this "board of special inquiry" are sent the aliens certified by the medical officers as suffering from loathsome or dangerous contagious disease, idiocy, epilepsy, and insanity.

In cases so certified the law is mandatory, and the medical certificate is equivalent to exclusion, the board simply applying the legal process necessary for deportation. Aliens certified by the medical officers as suffering from disability, likely to make them public charges, are also held for examination before the board of special inquiry. The board in these cases takes into consideration the medical certificate and such evidence as may be adduced by the alien or his friends which, in the opinion of the board, would offset the physical disability. In these cases the board has full discretionary powers, and in a great majority of instances the alien is admitted. Those certified as defective by the doctors group themselves naturally into four classes, and the following table indicates the disposition of such cases by the boards of special inquiry at New York during a fairly representative month:

DISPOSITION OF IMMIGRANTS CERTIFIED AT ELLIS ISLAND, N. Y., MONTH OF OCTOBER, 1903.

	Class I. (Dangerous Contagious.)	Class II. (Insanity and Idiocy.)	Class III. (Loathsome.)	Class IV. (Likely to become a Public Charge.)
Cases pending beginning of month	10	0	0	30
Cases certified during month	83	1	1	393
Total to be accounted for	93	1	1	423
Cases deported	61	1	1	30
Cases landed	4	0	0	349
Cases pending close of month	28	0	0	44

Immigrants not detained for the board of special inquiry have their money changed into United States currency, and buy their railroad tickets, under the supervision of government officers. If they are destined to points beyond New York city, government supervision is maintained until they are taken to one of the great railroad terminals and placed upon the waiting train. These precautions are taken to protect the immigrants from the boarding house "runners" and other sharpers who lie in wait for them at the Battery. Aliens detained as not clearly entitled to land are brought before the board, and, if the evidence is complete, either deported or discharged. When the evidence is incomplete, the immigrant is detained pending the verification of his story, or the arrival of his relatives or friends. All cases are disposed of as rapidly as possible, and immigrants are detained the minimum amount of time required for procuring and carefully considering the evidence in the case. Those ordered deported are returned to the ship as soon as possible after the decision is rendered, providing no appeal is made.

Missionaries and representatives of various religious denominations and societies have offices upon Ellis Island and render valuable assistance to the immigrant. They provide temporary shelter and protection for discharged aliens, and direct them to legitimate employers of labor. In this way they relieve the government of caring for many temporarily detained aliens, especially young women traveling alone. They write letters and send telegrams to the friends of the detained immigrants, and assist them in many other ways.

The fine adjustment of details and perfection of system which enable the federal officers at Ellis Island to examine, under our laws, thousands of aliens each day must be seen to be fully appreciated. Nor is this careful and strict execution of our laws limited to Ellis Island. The writer has roughly described the inspection at New York, because it is our largest port of entry, but the same attention to detail and strict enforcement of laws and regulations can be said to exist at all our ports, and an investigation, by any one interested, will reveal the fact that not only are the laws for our protection strictly enforced, but their enforcement is marked by humane and kindly treatment of the alien.

SOME COTTON FIGURES.

Some figures just supplied to a distinguished member of Congress by the Department of Commerce and Labor, through its Bureau of Statistics, suggest the possibilities which await the cotton manufacturers of the United States when they may find time to enter seriously upon the task of turning into the manufactured state the cotton produced in this country and now supplied in the natural state to the manufacturers of other countries.

The figures in question show merely the exportation of cotton manufactures from Japan to China during a term of years, but as Japan draws largely from the United States the raw cotton with which it produces the manufactures in question the suggestion which they offer is naturally an interesting one to us. These figures of exports of cotton manufactures from Japan to China show that the total value of cotton yarns exported from Japan to China in 1893 was $29,580, and in 1903 $14,112,507; and of other cotton manufactures in 1893 $221,783, and in 1903 $2,013,547, making the total of cotton yarns and finished cotton manufactures sent from Japan to China in 1893 $251,363, and in 1903 $16,126,054.

Meantime the quantity of raw cotton exported from the United States to Japan has grown from 793,24[illegible] pounds in 1893 to 161,601,219 pounds in 1900, the value of the same being in 1893 $68,423, and in 1900 $12,712,619. The quantity and value in 1903 were somewhat reduced by reason of the very high price of American cottons and the fact that Japan in years of high prices in America turns for a part of her cotton supply to India, where she finds a shorter staple and therefore lower prices. The general fact, however, that Japan increased her purchase of our raw cotton from 68 thousand dollars in 1893 to 7½ millions in 1903, and in the same period increased her sales of manufactured cotton to China from 251 thousand dollars in 1893 to 16 million dollars in 1903, suggests the possibilities which await the cotton manufacturers of the United States when they may choose to turn the cotton produced in this country into the finished state before permitting it to pass to the cotton consumers of the world.

This industry, which has recently sprung up in Japan, of buying American cotton, turning it into the manufactured state, and selling it to other countries is, of course, merely a reproduction of a process which has been going on for many years in the older manufacturing countries of Europe. The United Kingdom, for example, took in 1903 125 million dollars' worth of cotton from the United States, basing this statement upon our figures of exports to that country; and in the same year exported 322 million dollars' worth of finished cotton goods and 36 million dollars' worth of cotton yarns. Germany in the same year bought 85 million dollars' worth of cotton from the United States, as shown by our own figures of exports to that country, and exported 80 million dollars' worth of cotton manufactures, of which 71 millions was finished goods and the remainder yarns.

France took in 1903 35 million dollars' worth of cotton from the United States, basing this statement again upon our export figures, and exported 35 million dollars' worth of cotton manufactures, practically all finished goods, the quantity of yarns exported being less than $1,000,000 in value. Japan, as already indicated, took in 1903 7½ million dollars' worth of cotton from the United States, as indicated by our export figures, and exported 20 million dollars' worth of cotton manufactures, of which but 4½ millions was finished goods, while 15½ millions was yarn.

The fact that yarns form a much larger proportion of Japan's exports of cotton manufactures than is the case with those of European countries is apparently due in part to the fact that her manufacturing establishments have not yet reached that stage of perfection in the production of finished goods which the older countries of Europe have attained; and in part, also, to the fact that the people of her largest customer, China, utilize yarns largely in the household manufactures of cotton cloths for domestic use, especially in years of high prices of finished goods. This is also true of the cotton exports of India, which in the year ending March 31, 1904, amounted to 34 million dollars, of which 28½ millions went in the form of yarns, largely to China and other oriental countries.

Figures recently compiled by the Bureau of Statistics show that the world's exportation of cotton manufactures amounts to about 653 million dollars annually, of which 400 millions goes in the form of cloths, 152 millions as miscellaneous finished goods, and 101 millions cotton yarns. Of the 653 million dollars' worth of cotton goods thus exported by the various countries of the world for which statistics are available, the United States, although producing three-fourths of the world's raw cotton, exported in 1904 but 22½ million dollars' worth of cotton manufactures, of which 14.7 millions was cloths, 7½ millions miscellaneous finished goods, and $172,300 worth cotton yarn. In the same year, 1904, her importations of cotton goods were 49½ million dollars in value, or more than twice as great as the exports of cotton goods in the same period.

THE LIGHT OF THE GLOW-WORM.

By Dr. T. Lamb Phipson.

Scientific observers often meet with scant justice at the hands of literary men; and recently it was asserted by a well-known writer that "absolutely nothing" was known about the light of the glow-worm. The fact is, we know as much about that marvelous phenomenon as we can ever hope to know of any of the great mysteries of nature. Justus von Liebig once said that Nature will answer all our questions, and these questions are our experiments. It is true that experiments often require much patience and a certain gift of observation with which every one is not endowed.

The electric commotions produced by the *Torpedo* and the *Gymnotus* have been traced, in these fishes, to a special organ, a complicated structure connected with their nervous system, as they have been investigated with considerable success by modern electricians. In the same manner the phosphorescent organs of the glow-worm and the fire-fly have, during the last half-century, been the subject of numerous inquiries, but with somewhat less success, because in this case the organ itself has not been so thoroughly distinguished and described, and the light is not produced by this organ directly, but by a secretion which issues

from it in the same manner as bile is produced by the liver or saliva from the salivary glands. This secretion has been called "noctilucine." It is a white, unctuous substance, devoid of structure, and drying up into thin, white, shiny films, like the mucine which issues from the body of the garden snail. It is probably as complicated in its chemical nature as are many other glandular secretions produced by animals higher in the scale.

Noctilucine is produced not only by the glow-worm (*Lampyris*) and the fire-fly (*Elater*), but by the *Scolopendra*, a myriapod or centipede not uncommon in the soil of our rose-beds and on our garden-walks about the middle of the month of September; by the *Pholas*, a mollusk that bores into the woodwork of seaports and ships; and by the tiny *Noctiluca miliaris*, which is the chief cause of the phosphorescence of the waters of the English Channel; not to mention the numerous gelatinous beings or polyps figured and described in my work on "Phosphorescence" (London, 1862), and which are washed by the waves upon the sands of our coasts.

It is more than probable that the peculiar substance noctilucine, which shines in the dark like phosphorus, is also produced by the decomposition of many organic substances—for instance, by the flesh of fish and by that of other animals; and I have recorded instances in which it has been observed on the skin of man himself in cases of illness, and in various animal secretions. I presume that it is also present sometimes in vegetable substances, such as potatoes, which show a phosphorescent light when they decay under certain conditions of temperature and moisture, and that it is the substance which causes the phosphorescence of certain fungi, such as the mushroom (*Agaricus*) that is not uncommonly met with in Italy at the foot of the olive-tree.

In all cases where noctilucine is present it yields the same kind of spectrum. When subjected to what is termed "spectral analysis" (that is, viewed through a slit and a prism) it yields a band of light extending between the spectrum lines E and F, which in the case of the brilliant fire-flies of the West Indies will continue sometimes as far as the line C. In this spectrum we see neither bright lines nor dark bands; it is what is termed a "continuous spectrum."

That the light of noctilucine will affect a photographic plate can be put in evidence in the following manner: On a small cardboard box with a perforated lid, and having a sensitive photographic plate at the bottom of it, a glow-worm is placed; and the whole being covered with a glass tumbler standing on two thick straws (so as not to exclude the air), it is left in a dark cupboard all night. In the morning it will be found that the image of the perforations in the lid of the box have been reproduced upon the photographic plate.

The chemistry of noctilucine is a complicated subject into which I cannot enter here. Its existence as a special product of decayed fish was first hinted at in 1862 in my little work already mentioned; and it was first described in a pamphlet which I reprinted from the Chemical News in 1875. A year later my discovery was confirmed by Prof. Ch. Robin and Dr. Laboulène of Paris, in their researches on the fire-flies of the West Indies.

I first obtained this curious product by allowing several large centipedes (*Scolopendra electrica*), which are not uncommon in my garden at Putney, to crawl about in a porcelain dish with vertical sides, covered by a sheet of glass. When irritated these centipedes secrete a considerable quantity of it, which shines in the dark for a long time after they have been allowed to escape. This was in September and October. Since I made these observations several artificial organic substances of a similar nature have been discovered; and numerous phosphorescent bacteria have been met with, besides the luminous infusoria described by Ehrenberg a great many years ago, which appear to possess the faculty of producing noctilucine.

With regard to the glow-worm and fire-flies being able, as it were, to extinguish their light at will, it is accounted for by the fact that the organ which produces the noctilucine is under the influence of the nervous system of these insects. It is well known how much, in the higher animals and in man himself, the secretions of the glands are under the control of the nerves. This is notably the case for the salivary glands, and the old expression, "His mouth waters at the sight of food," is an apt illustration. I believe that in the little *Noctiluca miliaris*, a tiny being in which no nervous system has yet been detected, and which causes the beautiful phosphorescence of the waves on our coasts, there must exist an organ which secretes noctilucine. These little melon-shaped animals, that are not so large as a pin's head, so long as they are quiescent come to the surface of the water and remain dark; but when the glass which contains the water is slightly struck with a pencil or the finger they sink down, and glow brightly like diamonds as they descend, as if their luminosity depended upon the movement and contraction of their bodies.

In all these cases of animal phosphorescence, the production of the light appears to be due to the oxidation or slow combustion of the light-giving substance by the air causing the gradual decomposition of the noctilucine; but this substance will shine for some time under water, until all the air in that liquid is exhausted. It has been noticed that the eggs of the glow-worm are luminous in the dark for some time after they have been deposited. The glands which secrete the noctilucine in the *Scolopendra electrica* are situated under the scaly rings of the centipede's body, like those which secrete the wax in bees. At a certain period of the year (about October) the common earthworm (*Lumbricus*) is highly phosphorescent, especially those found in warm dunghills; and when their light is viewed through a spectroscope it also gives the spectrum of noctilucine which I have already described.—Chambers's Journal.

ELECTRICAL NOTES.

Letters patent have recently been granted to Mr. John McIntyre, of Jersey City, for an electro-magnetic apparatus. The object of the invention is to provide an apparatus for the stimulation and vitalizing of live animal or vegetable objects by saturating, for instance, the whole human or animal object or the bed-soil of the vegetation uniformly with electricity in its normal condition, magnetism, by the employment of frequency magnetism derived from an electric cable-coil in circuit with a source of variable electric energy or frequency electric currents, such as alternating currents. The advantage this method possesses over others lies in the pliable cable-coil. By means of it, objects of almost every size and shape may be surrounded by the cable, which is preferably compactly coiled. Moreover, the magnetic effect may be closely regulated, decreased or increased, by the shape of the surrounding coil. This is due to the fact that the density of the magnetic field depends upon the condition and proximity to each other of the conductors carrying the current.

The usual acidulated liquids employed in accumulators have many disadvantages, especially when the cells are carried in motor vehicles or in other circumstances where they may be subjected to much shaking and vibration. The liquids are liable to be spilt or to penetrate through stoppers and corrode the terminals or wires and cause other annoyances. For this reason they have sometimes been replaced by pastes or jellies. M. Schoop, who has lately been experimenting in this line in France, gives the following preparation as one very suitable for the purpose: (1) A solution of sulphuric acid in distilled water, having a specific gravity of 1.22. (2) A solution of silicate of soda, free from chloride, in distilled water, with a density of 1.20. (3) A "bouillon" obtained by boiling for two hours in an enameled receptacle one kilogramme of asbestos card with two liters of water acidulated with 10 per cent of sulphuric acid. The cardboard disintegrates and is washed over a filter with distilled water, and is then squeezed as dry as possible by hand so as not to retain more than one-third its weight of water. Take 18 liters of the acid solution No. 1, add 450 grammes of the wet asbestos fiber, and thoroughly mix in a glass or ebonite vessel. Rapidly pour in 4½ liters of the solution No. 2, and stir until it assumes an oily appearance. Then pour the composition into the accumulator, the plates having been moistened with acidulated water, and leave for 24 hours to settle. The liquid gradually thickens, and finally becomes a solid jelly.

In the latter part of December, 1904, a 5,500-kilowatt, 25-cycle turbo-generator built by the Electric Company was put in operation in the 74th Street Station of the Interborough Rapid Transit Company, New York. It was the first Westinghouse unit of this size to be put in service, although a number of similar machines are approaching completion. The next day after this machine was put in service, it carried loads as high as 8,000 kilowatts, and for considerable periods loads between 7,000 and 8,000 kilowatts were of common occurrence. This turbo-generator is the largest now in service. Within a few days after the machine was put in service, and while operating in parallel with six of the slow-speed 5,000-kilowatt machines in the same station, a short-circuit occurred among the main leads at a point between the turbo-generator and the switchboard. This was a dead short-circuit and it tripped the automatic switches on all the slow-speed machines, which were set at almost three times full-load current, but did not trip the safety switches on the turbo-generator on account of the fact that the arc was so violent that it burned off the leads to the safety devices for this particular machine, though these leads were in a separate conduit. It was necessary to cut the turbo-circuits off by hand and the short-circuit therefore continued on this machine some little time before it was cut out. Careful examination of the generator showed that it was absolutely uninjured in any way, as far as could be determined, and was ready for service immediately afterward, but could not be thrown in with the other machines on account of the main leads to the switchboard being burned off. The machine has been in service with heavy loads since these leads were replaced. The 5,500-kilowatt turbo-generator is run in parallel with the other machines in the station and the only notable difference in its operation and that of the slow-speed machines is due to the difference in the speed regulations of the two types of engine. The steam turbine was adjusted so that it regulated much more closely in speed than the low-speed engines and, in consequence, the turbo-generator takes the fluctuations in load. It is noted that when the turbo-generator is operating in parallel with the slow-speed machines, the latter machines carry a much steadier load than when the steam turbine is cut out, the turbine unit appearing to take all the fluctuations when it is in circuit. This unit, therefore, has something of the effect of a flywheel or a storage battery on the system. This effect, if considered undesirable, can be modified readily by adjusting the speed characteristics of the steam turbine. On account of its uniform rotative velocity and its relatively large flywheel capacity, the turbo-generator is particularly suitable for operating rotary converter systems such as the Interborough. Such machines also operate extremely well in parallel, and the operation of a steam turbine unit with a reciprocating unit is, in general, considerably better than reciprocating units with each other, due to the fact that the mean rotative velocity of the combined units is better than in the case of reciprocating units alone. In the case of the Interborough slow-speed generators, this effect is not noticeable, as there is no evidence of periodic speed fluctuations in the slow-speed units, due to a large extent to the heavy dampers on the machines, their large fly-wheel capacity, and the proportions of the engines which are designed for very small angular variation. Some months ago a series of tests was made to determine the paralleling qualities of turbo-generator units. At full voltage the machines ran perfectly in parallel. Fluctuations in speed were so slight that periods from one to fifteen seconds could be obtained for synchronizing. When the voltage was reduced to 60 per cent of the normal, the machines would carry the full current without any evidence of hunting. The voltage was further reduced and tests were made, until about 15 per cent of the rated voltage was obtained. Under these conditions the machines still remained in parallel when carrying full-load current, but the conditions of paralleling were not perfectly stable, the load being transferred from one machine to the other at an irregular but not rapid rate. As the synchronizing power varies approximately as the square of the voltage, it was extremely low in the last test cited. It is evident, therefore, that but small interaction is required between such machines to maintain parallel operation.—Electric Club Journal.

SCIENCE NOTES.

We have nearly reached the limit in river pollution, says Mr. C. M. Woodward. The public welfare will soon make an imperative demand for a halt. A great city like Chicago shall no longer load with poison a little stream like the Illinois, nor foully pollute a great river like the Mississippi. Let me frankly admit that even the city of St. Louis shall not forever dump and pour its refuse into the Mississippi River.

When the national government takes up the function of guarding every stream from pollution (and no State government can deal effectively with the problem) we shall have a great extension of the sphere of sanitary engineering. The recent discoveries by Dr. George T. Moore, of the Department of Agriculture, suggest the possibility of purifying a polluted stream so as to make it not only clear and sweet, but absolutely free from algæ and all harmful bacilli. The proper disposition of house drainage and the refuse of factories is already a live engineering problem in Europe, and American engineers must no longer neglect it. The study of diseases and their prevention is forcing its way into engineering schools, as preliminary to extensive engineering practice. Whatever form the solution of the problem may take, it will involve both chemical and hydraulic engineering, and the fundamental principles of both must be carefully laid in our schools.

In the Zeitschrift anorg. Chemie, Messrs F. Haber and S. Tolloczko contribute an article upon the reduction to carbon of chemically-combined carbonic acid, of which an abstract appears in the Journal of Chemical Society. Solid sodium hydroxide was fused in an iron dish; it was then cooled, and as soon as it solidified was electrolyzed by a current of 0.15 ampere and 11 volts, and finally at 200 deg. with 1 ampere and 5 volts. The yield of sodium was 39 to 46 per cent. Barium chloride was electrolyzed at a temperature 400 deg. below its melting point. When barium carbonate is added to barium chloride, carbon is formed at the cathode in quantitative amount. By aid of sodium, barium carbonate is readily converted into oxide, while carbon separates. Barium chloride and barium carbonate were fused together in a nickel crucible, allowed to cool, and then electrolyzed at 550 deg. to 600 deg., the cathode consisting of iron, platinum, or graphite. Carbon separated in a dendritic form. The E. M. F. between 550 deg. and 580 deg. varied from 6 to 10.4 volts, while the current strength varied from 22 to 45×10^{-3} amperes. In the experiments with graphite electrodes, the latter were not attacked. During the electrolysis of barium chloride in a Hempel furnace, carbon was formed at the cathode, owing probably to the action of carbon dioxide and oxygen present in the heating gases on barium chloride, a reaction which proceeds thus: $BaCl_2 + CO_2 + O = BaCO_3 + Cl_2 - 11{,}850$ cal. The analogous reaction with calcium chloride, proceeding according to the equation $CaCl_2 + CO_2 + O = CaCO_3 + Cl_2 + 1{,}550$ cal., was studied. Chlorine is also produced in an analogous manner by the action of carbon dioxide and oxygen on sodium chloride. No carbon was obtained when barium chloride was electrolyzed in an electric furnace at about 600 deg. in an atmosphere of nitrogen. For the formation of barium and nickel chlorides as products of the electrolysis of solid barium chloride with nickel anodes, a polarization of 2.65 volts would be expected according to the equation $Ba + NiCl_2 = BaCl_2 + Ni + 122{,}400$ cal. The value of 1.9 volts was found corresponding with the free energy of formation of solid barium chloride and nickel from the reaction $2BaCl + NiCl_2 = 2BaCl_2 + Ni$; the reaction $Ba + BaCl_2 = 2BaCl + 34{,}600$ cal. corresponds with 0.7 volt. Determinations of the E. M. F. of two solid Daniell cells, $PbCl_2/AgCl$, agreed with the calculated value 0.519 volt.

ENGINEERING NOTES.

Eighty-five and six-tenths per cent of the freight cars of the United States now have air brakes, according to the last report of the American Railway Association.

A new method for improving the properties of slag cement has recently been described by Herr Karl Zulkoski, professor of chemical technology in the German high school at Prague, Austria. He says that it is a well-known fact that furnace slag slowly cooled in air possesses no hydraulic properties. In this condition it is known as ortho-calcium-silicate. To impart hydraulic properties to such slag it must be converted into dicalcium silicate by suddenly chilling the slag in cold water; the colder the water the higher the hydraulic properties imparted. The water granulates the molten slag and about 40 per cent of each individual granule becomes strongly hydraulic. When molten slag is chilled in lime water or other alkaline water, the slag will absorb the alkaline properties of the water and become hydraulic in a still higher degree. Molten slag, however, chilled in cold milk of lime will become hydraulic in the highest degree, and when ground will, in tensile and compressive strength, equal Portland cement.—Stone Trades Journal.

The remarkable continuous run of the Westinghouse steam turbine at the St. Louis Exposition deserves a conspicuous place in the permanent record of steam engineering, says the American Machinist. This 600-horse-power turbine was started in the Palace of Machinery at 9:20 A. M., June 20, and was stopped at 11:32 A. M., December 2, the elapsed time being 3,962 hours. As the speed maintained was 3,600 turns per minute, the total number of rotations was 855,792,000, or approaching the billion mark. The work done varied from 25 per cent underload to 25 per cent overload. The turbine, after its stoppage, was examined by a responsible committee and was found in perfect condition, with practically no wear discoverable, the tool marks still remaining on the bearings. There have been at least two instances in America in which reciprocating piston engines have been run continuously for as long a period as this record run of the Westinghouse turbine, but, of course, the speed of rotation was not one-tenth as great. The Machinist printed in 1903 an account from New South Wales of a continuous run of six years by a 250-horse-power compound condensing engine, built in Leeds, England. It seems to be possible to run engines as long as may be required except for wear or breakage, and the steam turbine minimizes these contingencies.

In an interesting paper read by C. M. Woodward at St. Louis, it was said that in the near future we are likely to make great progress in the construction of rolling stock and moving machinery, as well as in the construction of bridges and buildings.

The adoption of electricity by railroads for all kinds of traffic will result, in the first place, in the disappearance of the heavy locomotive. So long as the locomotive was needed to pull a long train of cars, great weight was necessary, and the weight of railway engines and the strength of bridges have been increasing at a rapid rate. We saw a locomotive at the recent fair at St. Louis weighing over 200 tons. It was a monster, indeed. Should such locomotives become common, every bridge in the country would have to be rebuilt.

But when each car, whether for passengers or for freight, has its own motor and drives itself, the heavy locomotive is no longer needed. Moreover, the car itself should be made as light as possible consistent with strength. Weight is of no advantage to a self-driven car. The bicycle has taught us a great lesson in the art of construction—a maximum of strength and stiffness with a minimum of weight. This already prevails in girders and bridge constructions. The same principles should be applied to all rolling stock and moving machinery. Tubular axles, tubular spokes, tubular fellies, tubular shafts, tubular everything is to be the law of future construction. All the great steam engines and propellers already have hollow shafts, and there will be a great increase in the amount and precision of hollow steel tubing manufactured and used in the next ten years. The mechanical and material advantage of tubular shafting is easily stated. Thus: (1) If a solid cylindrical shaft be compared with a hollow shaft of the same weight per foot of length, but whose exterior diameter is n times as great, the strength of the hollow shaft in torsion is $2n - 1/n$ times as great as that of the solid shaft. (2) If only equal strength is required, the solid shaft having one nth of the diameter of the tube, will weigh $2n - 1/n^2$ times as much. For a numerical example: (*a*) A thin tubular shaft four inches in diameter is seven and three-fourths times as strong as a solid shaft one inch in diameter which weighs the same per linear foot.

(*b*) A solid shaft weighs seven and thirty-one thirty-seconds (call it eight) times as much as a tubular shaft of equal strength and four times its diameter.

The ratio of stiffness of the tube to that of the solid shaft is even greater.

At the recent St. Louis fair a prize of $2,500 was offered for the lightest motor per horse-power. Motors up to 100 horse-power were eligible. The prize was not awarded, for the reason that inventors and constructors of motors were not prepared to submit their apparatus to the rigid tests required for efficiency and durability; but the offer was made with distinct intention of stimulating the construction of motors which should be suitable for vehicles where lightness combined with great strength is a desideratum, such as in automobiles and airships.

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